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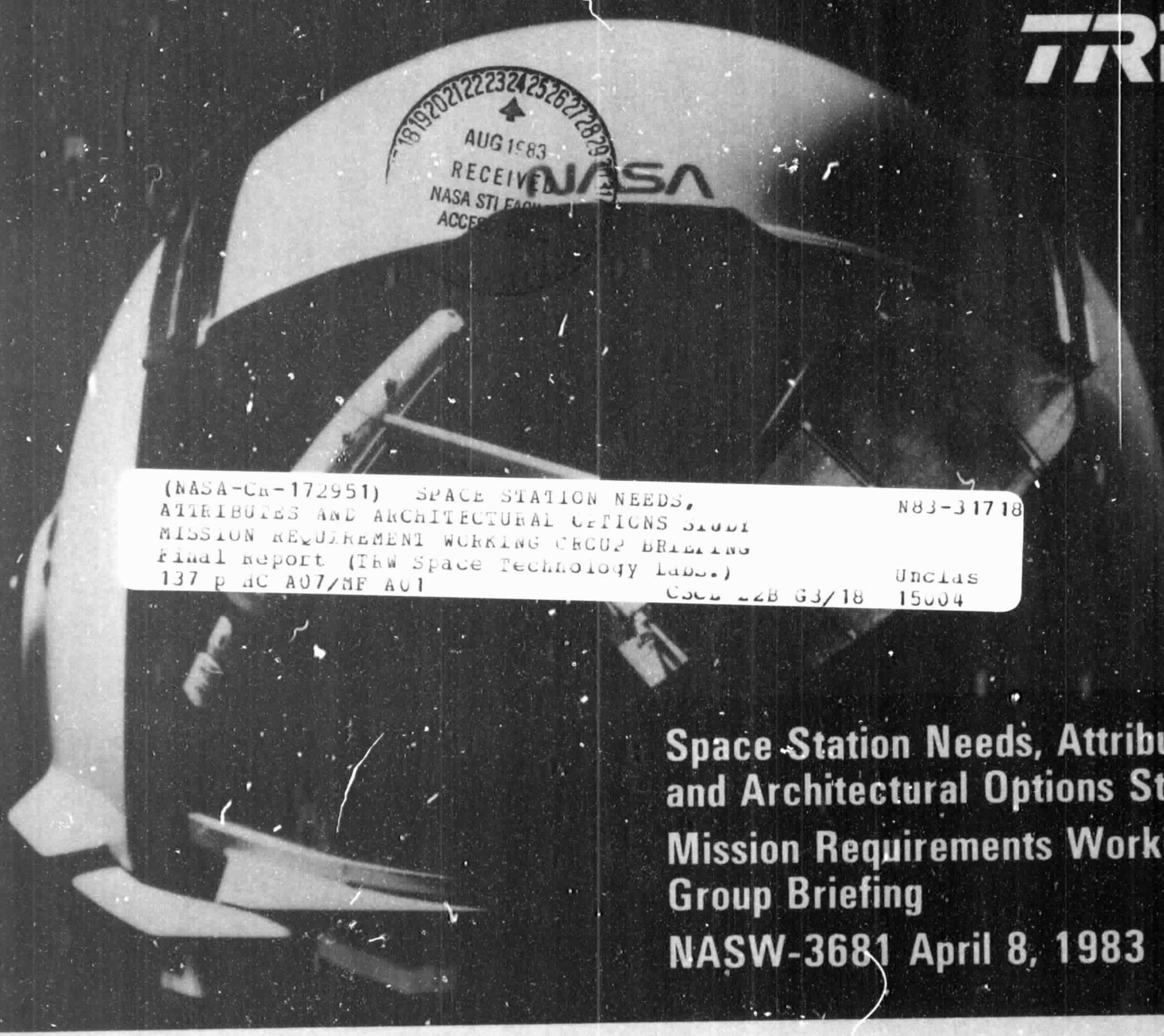

(NASA-CR-172951) SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS STUDY MISSION REQUIREMENT WORKING GROUP BRIEFING Final Report (TRW Space Technology Labs.) 137 p HC A07/MF A01 CSCL 22B G3/18
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Space Station Needs, Attributes and Architectural Options Study

Mission Requirements Working Group Briefing

NASW-3681 April 8, 1983

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MISSION REQUIREMENTS TOPICS

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- REQUIREMENTS SOURCES
- REQUIREMENTS FLOW
- ORBIT SELECTION
- MISSION MODEL
- KEY MISSIONS
- INTEGRATED, PHASED REQUIREMENTS
- MISSION BENEFITS

Requirements Sources

MISSION REQUIREMENTS SOURCES

Mission requirements were developed from a number of sources for each of the space station mission categories. Science and applications requirements were obtained through analysis of a number published reports sponsored by NASA and the National Academy of Sciences Space Science Board. The result of this analysis, providing traceability from science mission requirements to the Space Science Board strategies, is included in the appendix of the TRW User Requirements and Benefits Catalog. This document, number NASW-3681 published March 18, 1983 is part of the TRW Space Station Study final report product. Materials processing user needs were drawn from members of the industrial community at a TRW sponsored workshop. The commercial communications and remote sensing requirements were developed from user surveys and analyses concluded by TRW consultants R. Filep, A. Loomis, and D. Walklet. For further detial on the sources of commercial and DoD mission requirements, see the respective space station working group briefing packages.

MISSION REQUIREMENTS SOURCES

MISSION CATEGORY	SOURCES
• SCIENCE AND APPLICATIONS	1. NAS SPACE SCIENCE BOARD STRATEGY PUBLICATIONS
	2. TRW SCIENCE PANEL
	3. TELEDYNE-BROWN SP DATA BOOK (3/82)
	4. OAST SPACE SYSTEMS TECHNOLOGY MODEL (9/81)
	5. DRAFT SCIENCE AND APPLICATIONS REQUIREMENTS FOR SPACE STATION (11/82)
	6. CONTACTS WITH SELECTED COMMUNITY MEMBERS
• COMMERCIAL	1. TRW MATERIALS PROCESSING WORKSHOP (10/82)
	2. COMMUNICATIONS COMMUNITY SURVEY (R. FILEP, CONSULTANTS)
	3. REMOTE SENSING MARKET ANALYSIS (CONSULTANTS A. LOOMIS AND D. WALKLET)

MISSION REQUIREMENTS SOURCES

Technology development and space operations requirements are based on a world-wide survey of the satellite manufacturing industry. Inputs were also supplied by the TRW Satellite Servicing Study team now under contract to NASA/MSFC.

In the DoD area, missions, requirements, and priorities were developed from a number of interviews with Defense and National Security contacts. Much of the detailed systems requirements are based on the specifications contained in the latest Military Space Systems Technology Model (MSSTM) published, January 1982.

MISSION REQUIREMENTS SOURCES (CONT)

MISSION CATEGORY	SOURCES
• TECHNOLOGY DEVELOPMENT AND SPACE OPERATIONS	1. SURVEY OF 14 US AND FOREIGN SATELLITE MANUFACTURERS 2. TRW SATELLITE SERVICING STUDY TEAM (MSFC CONTRACT)
• DoD	1. CONTACTS WITH MILITARY USER ORGANIZATIONS 2. MILITARY SPACE SYSTEMS TECHNOLOGY MODEL (MSSTM, 1/82)

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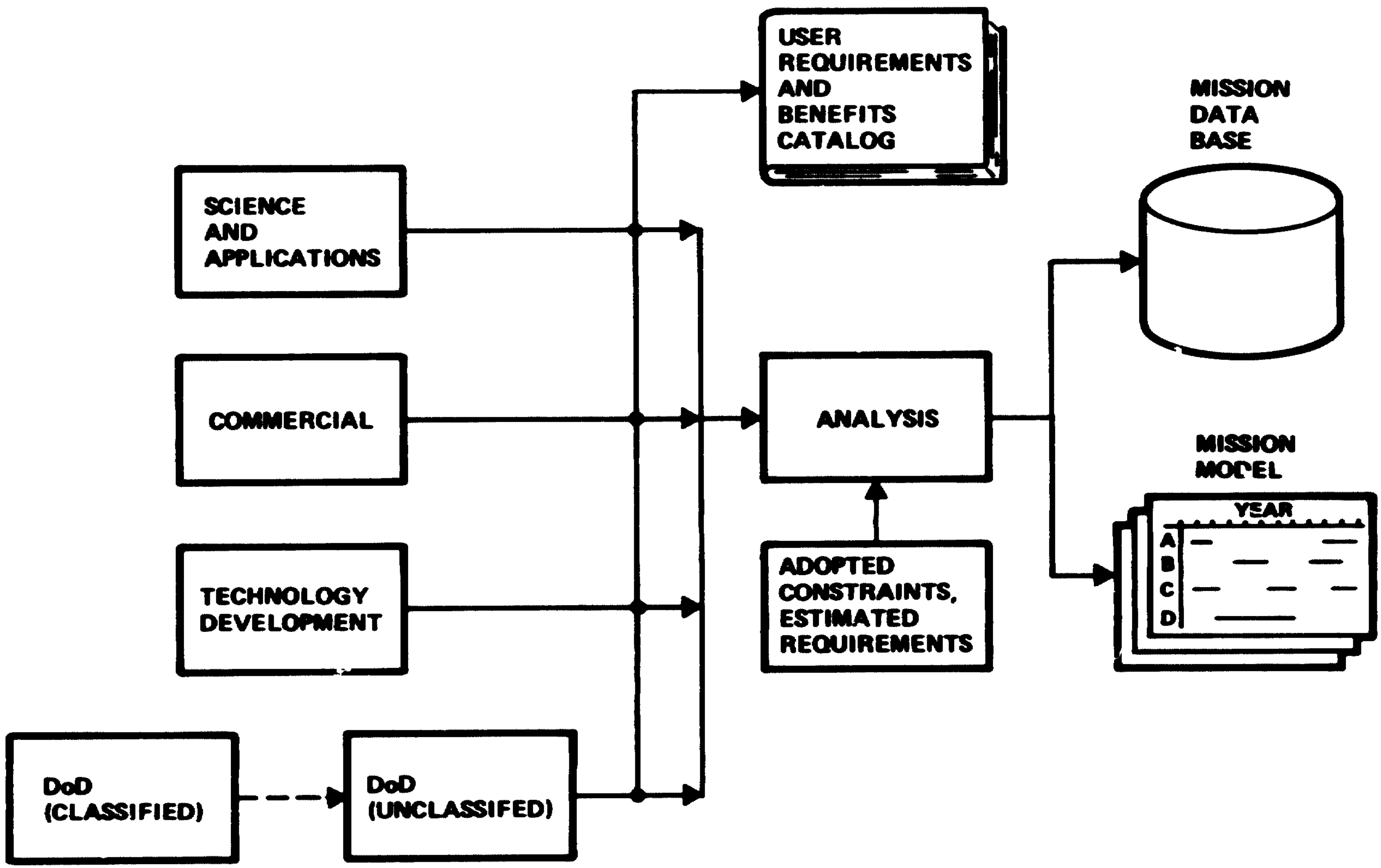
Requirements Flow

MISSION REQUIREMENTS FLOW

The user requirements obtained from the different mission areas are first recorded in the User Requirements and Benefits Catalog. The catalog is one output of the TRW space station study and provides a reference for all of the missions considered in the mission requirements task. Classified portions of the DoD mission requirements are restricted to the special DoD portion of study effort. Unclassified requirements are passed-on, to be incorporated with the other civilian sector requirements. The entire set of missions and requirements are accumulated and subjected to a set of priorities and constraints to form a single integrated mission model that phases all missions in time. As indicated, requirements values are estimated in cases when the user supplied information is insufficient. The mission data base is a computer based file that records each mission's requirements data. The data base plus the mission model input provides the data set for evaluation of time phased integrated mission requirements.

MISSION REQUIREMENTS FLOW



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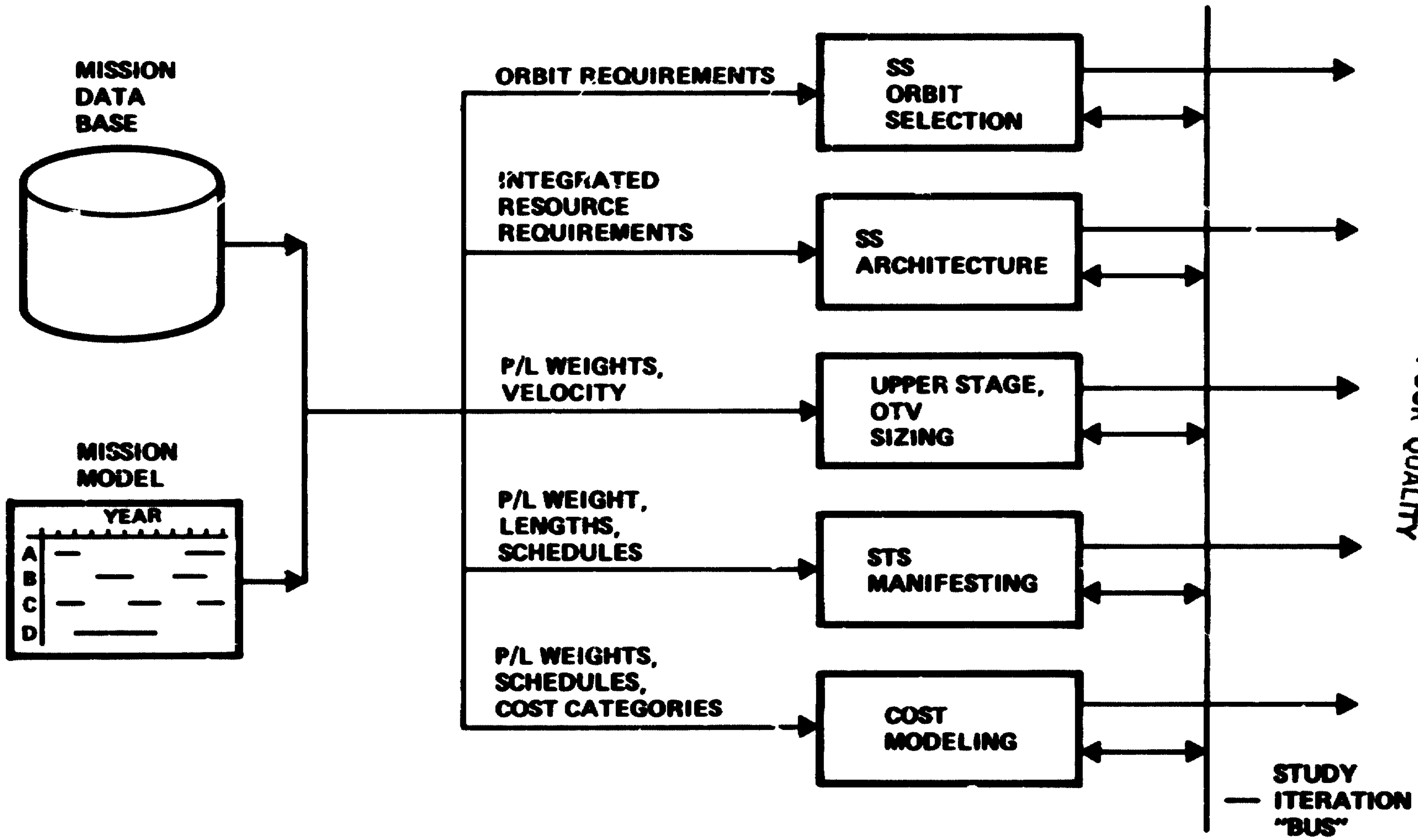
The mission model and data base contribute to all of the evaluation activities of the space station study. Orbit requirements and payload resource requirements are used to determine the selected orbits and facility sizes and capabilities for the space station architecture. Mission payload weights and maneuver velocity requirements are used to size propulsion and orbit transfer vehicle capabilities. Payload weights and mission model schedules, along with space station assembly and operation, drive the STS manifest. Payload weight, selected cost categories and complexity factors are used to evaluate missions costs in the costing portion of the space station study.

This chart reflects just the initial destinations of the mission requirements data. As indicated, the process has been highly iterative on the results of the different evaluation portions of the study.

MISSION REQUIREMENTS FLOW (CONT)



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Orbit Selection

SS ALTITUDE

The space station altitude is subject to a number of factors the most important being the basic shuttle lift capability. This confines the space station to relatively low altitudes; the exact altitude is selected for the space station depending on the parameters and constraints identified in the chart. The indicated narrow range of altitudes is acceptable to many low earth orbit missions. Missions in low earth orbit that are not immediately compatible with the space station orbit can use either a SS-based Teleoperator Maneuvering System (TMS) or self-contained propulsion to access space station services. Missions requiring a non-low earth orbit such as missions in geosynchronous orbit require an orbit transfer capability, possibly provided by an SS based orbit transfer vehicle (OTV).

SS ALTITUDE

- ALTITUDE CONSTRAINED BY SAFETY AND CONTINGENCY CONDITIONS
- MINIMUM SAFE ALTITUDE IS APPROXIMATELY 300 KM (160 NM)
- SELECTED ALTITUDE MINIMIZES LOSS OF USEABLE STS PAYLOAD AND DEPENDS ON

  STS TRAFFIC LOAD

  SS SIZE

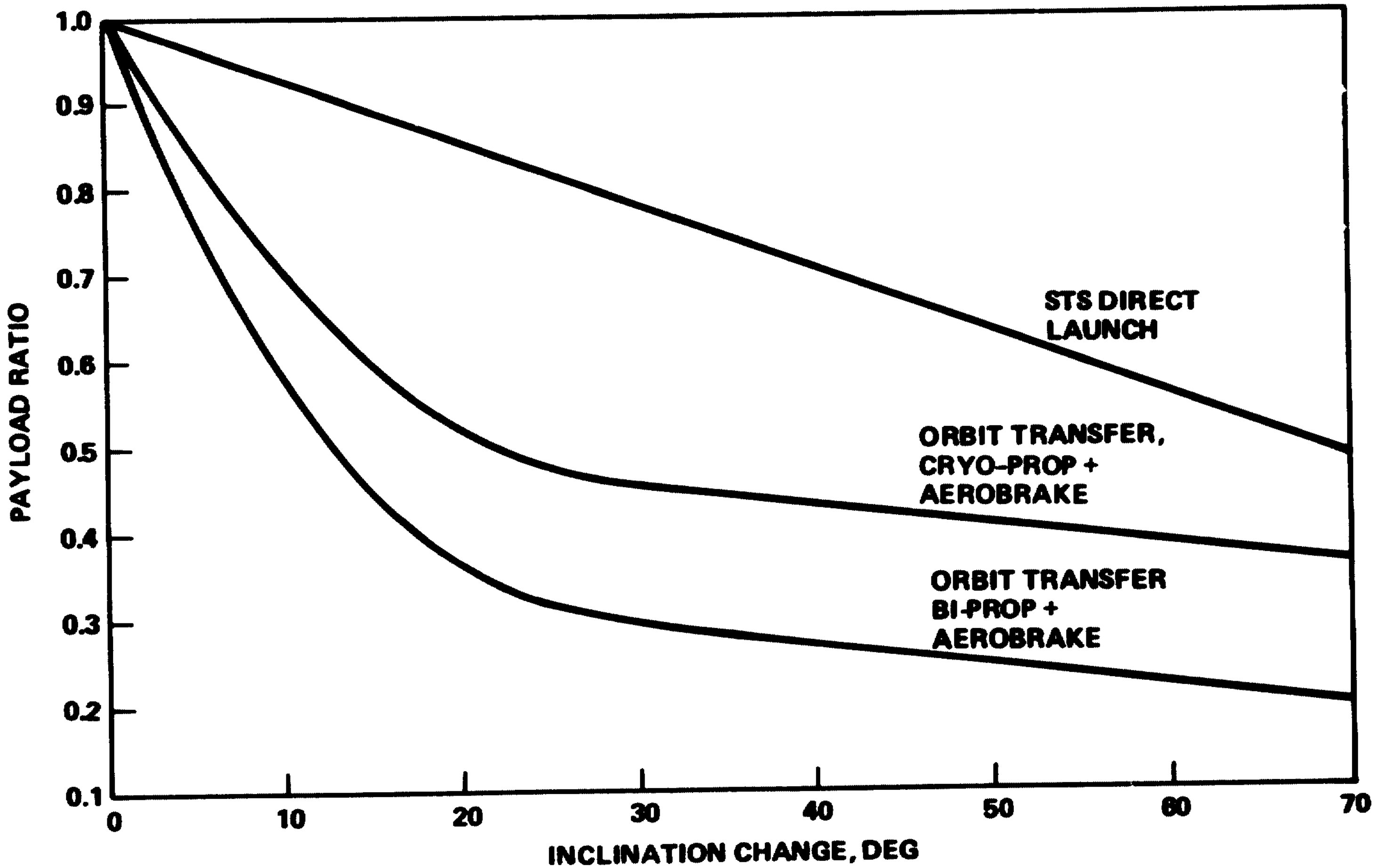
  SOLAR CYCLE
- ADOPTED APPROACH IS AN ADAPTIVE SPIRAL-IN, SPIRAL-OUT STRATEGY
- RENDEZVOUS WITH ORBITER AT ALTITUDES BETWEEN 300 AND 340 KM (160 AND 185 NM)

INCLINATION BY DIRECT LAUNCH VS. ORBIT TRANSFER (LOW EARTH ORBITS)

This chart addresses the options of achieving orbital inclinations either by direct shuttle launch or by transfer from an intermediate orbit. These results apply to the question of whether a single space station can economically service free flyer vehicles in widely spaced inclination orbits. It is shown that using a single facility incurs large performance penalties in comparison to directly launching payloads and vehicles with the shuttle. Therefore, the space station architecture must provide facilities in multiple orbit inclinations to service the wide variation of mission inclination requirements.

The chart assesses transportation performance in terms of payload ratio. In the case of the shuttle, this is the ratio between the STS capability at a lower inclination (28.5°) and its capability at higher inclinations. The orbit transfer ratios are the final mass to initial mass ratio computed for the increasing transfer velocity requirement. The transfers assume near optimal three-impulse maneuvers using aerobraking for final circularization. The sensitivity to propulsion performance (cryogenic vs. bipropellant) is also indicated.

INCLINATION BY DIRECT LAUNCH VS ORBIT TRANSFER (LOW EARTH ORBITS)



- DIRECT LAUNCH BETTER FOR OTHER THAN VERY SMALL INCLINATION CHANGES
- SIGNIFICANTLY DIFFERENT INCLINATIONS REQUIRE SEPARATE SS FACILITIES

SS FACILITY INCLINATION OPTIONS

A range of facility inclinations is considered to determine the best approach for meeting the wide range of mission inclination requirements. The option at 57° is rejected at the outset since it neither uniquely satisfies enough missions to play a role in a multiple-facility scenario nor is it a good enough compromise between STS performance and science requirements to serve as a sole space station option. Thus facilities spaced at low and high inclinations are called for. The 28.5° inclination facilities can accommodate nearly all low inclination missions. The high inclination case is more complicated and will be further addressed in the following.

SS-FACILITY INCLINATION OPTIONS

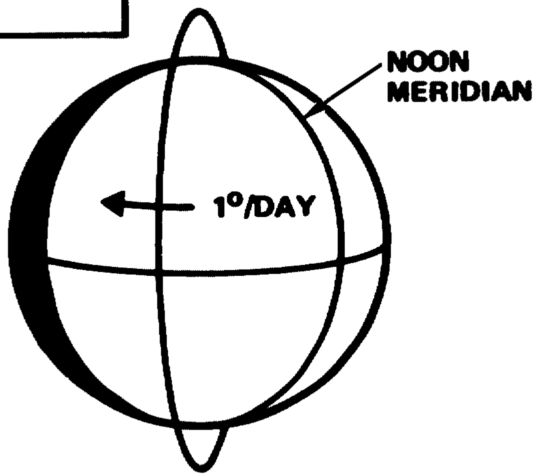
OPTION	CHARACTERISTICS	IS CANDIDATE
1. 28.5°	SATISFIES HIGH-TRAFFIC MISSIONS, HEAVY ASTROPHYSICS FACILITIES	YES
2. NEAR 57°	COMPROMISES SCIENCE REQUIREMENTS, STS PERFORMANCE	NO
3. NEAR 90°	COMPLETE EARTH COVERAGE	YES
4. NEAR 97°; SUN SYNCHRONOUS	NEEDED FOR OPERATIONAL LAND, WEATHER, COMMERCIAL EARTH RESOURCES, AND DoD MISSIONS	YES

SUN SYNCHRONOUS ORBITS

The question of high inclination facilities divides between near polar or polar orbits and sun synchronous orbits. The sun synchronous orbits provide, in addition to essentially full earth coverage, constant sun angle and local time observation conditions. These are critical to operational-type weather, earth resources and some military surveillance missions. The issue of a single facility location is additionally effected by the need by different missions for different orbit nodal orientations. In the case of the sun synchronous orbits, the node is specified in terms of the local time the orbit crosses earth's equator.

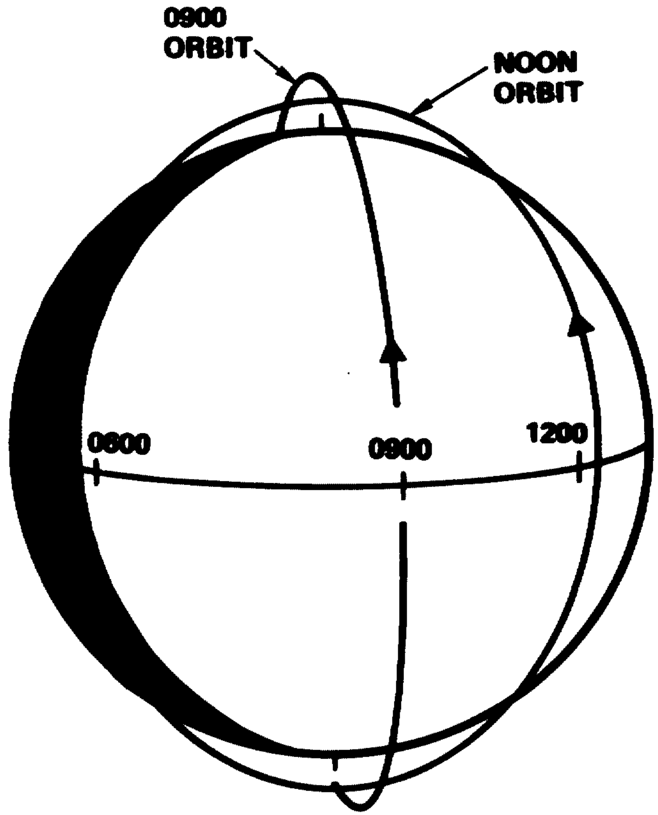
SUN SYNCHRONOUS ORBITS

POLAR ORBITS DRIFT RELATIVE TO SUN



- SPECIFIC MISSIONS NEED DIFFERENT NODE ANGLES
- DIRECT ORBIT TRANSFER BETWEEN NODE ANGLES PROHIBITIVE
- TRANSFER FEASIBLE USING DRIFT ORBITS
  ~3 HR CHANGE IN 3–6 MONTHS

SUN SYNCHRONOUS ORBITS REMAIN FIXED RELATIVE TO SUN



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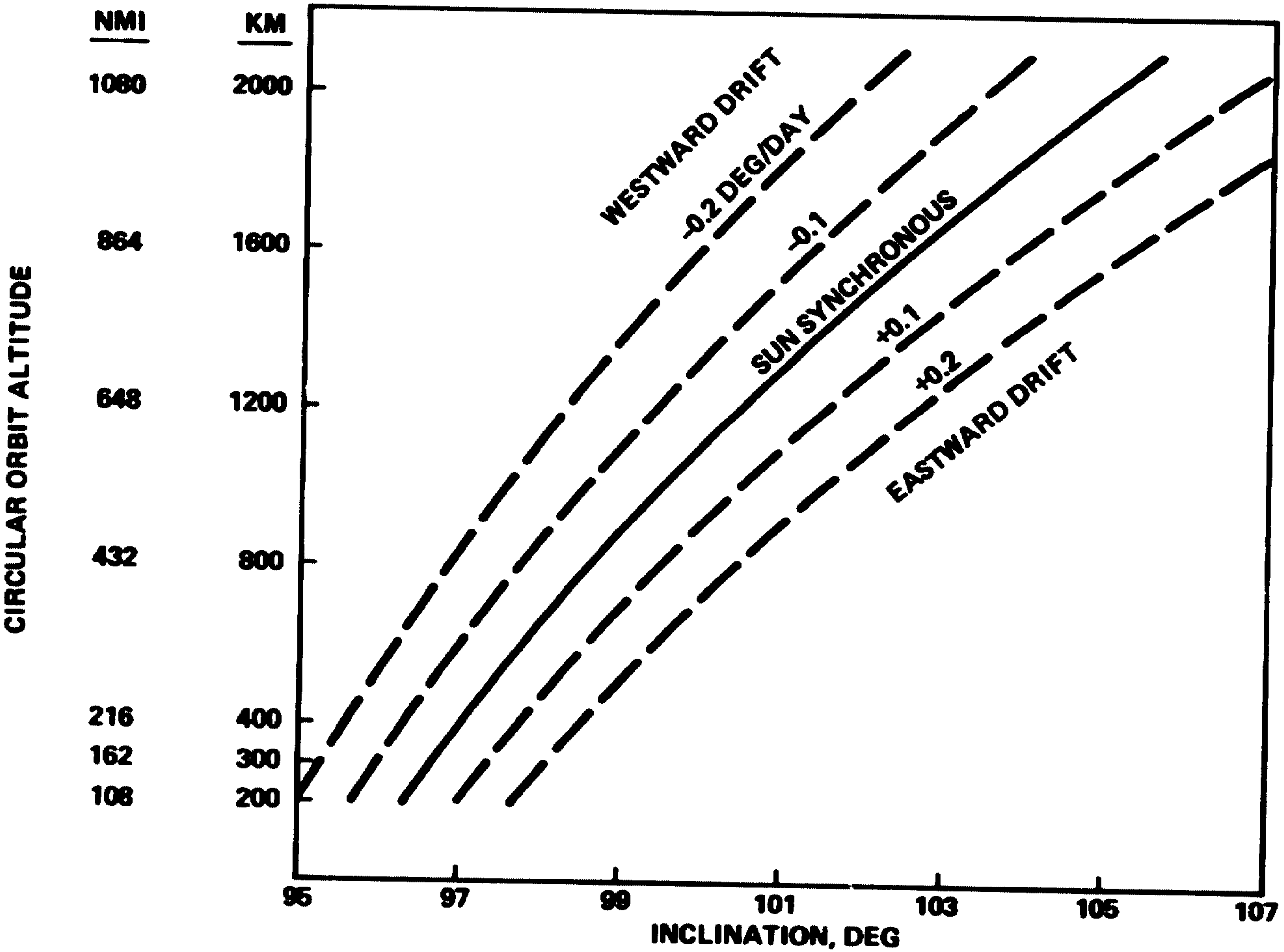
NEAR SUN SYNCHRONOUS ORBITS

A single space station facility in a given sun synchronous orbit, can be accessed by vehicles in nearby sun synchronous nodes by using drift transfer orbits. This is accomplished by executing maneuvers to modify orbital inclination and altitude to effect a drift rate in the node position. Moderate drift rates up to 0.5 deg/day are feasible without excessive propulsion requirements (ΔV of $\sim$ 3000 fps). Correspondingly, nodal transfers of $\pm$ 3 hours are achievable in one-way transfer times of 90 days.

NEAR SUN SYNCHRONOUS ORBITS



DRIFT ORBITS CAN BE USED TO TRANSFER TO NEAR-BY SUN SYNCHRONOUS NODES

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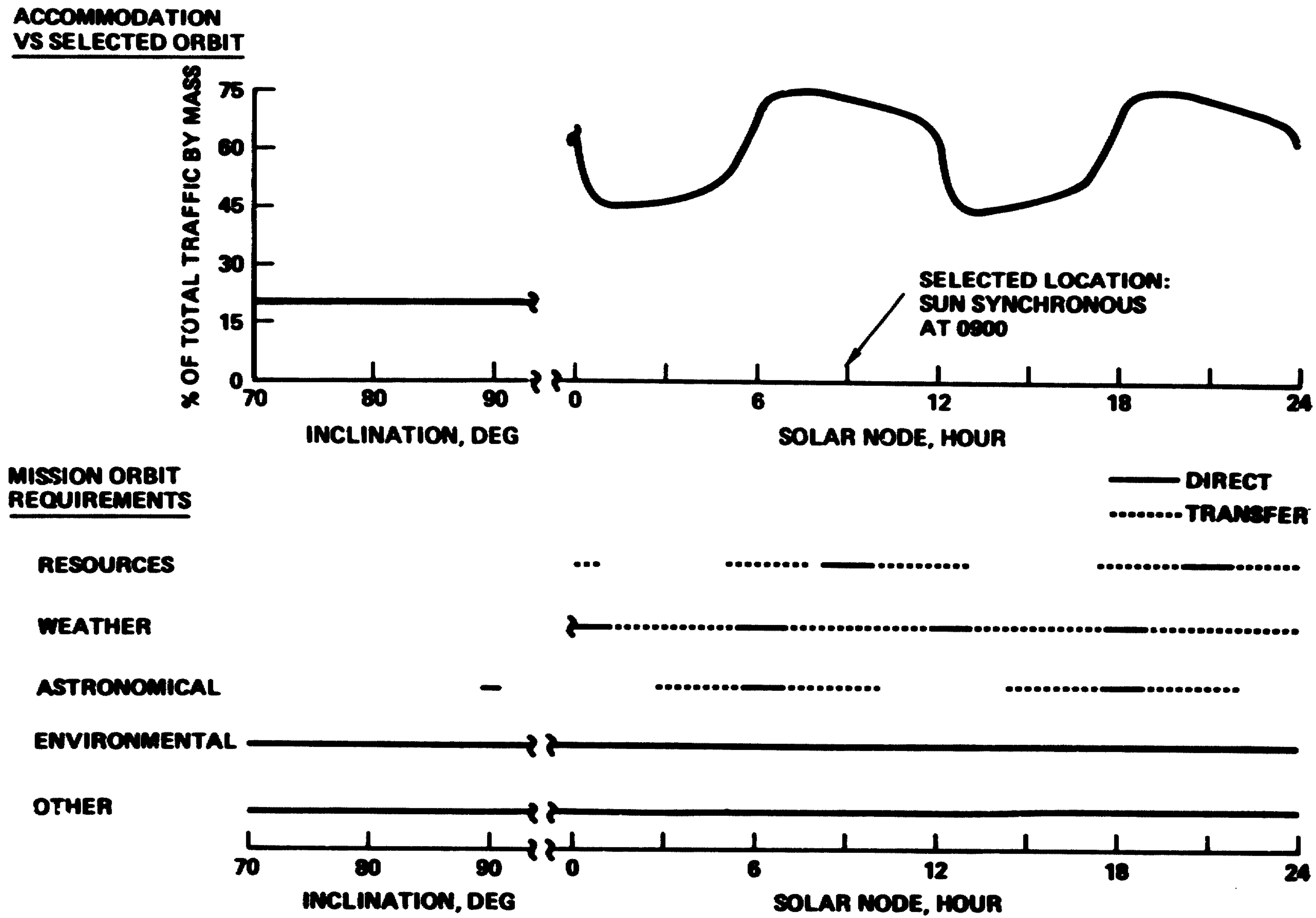
ORBIT SELECTION VS DISTRIBUTION OF POLAR PAYLOADS
1995-2000 LEO MISSIONS

This chart assesses accommodation of high inclination missions by a single polar facility at a location within the range of inclinations, 70°-97° and all sun synchronous nodal positions. The utility of the facility is measured in terms of the total mission traffic (by mass) serviceable by the facility. The facility can be manned or unmanned and supports missions by providing payload deployment, servicing, retrieval, and platform accommodations. For sun synchronous facilities it is assumed that missions in ± 3 hour nodal positions can be accommodated using drift-orbit transfers.

The assessment indicates that the most effective single-facility locations are sun synchronous. The mission traffic is maximized for nodal locations between 0600 and 1200 (or 1800 and 2400). The 0900 location is well placed for earth resource observations and is chosen as the preferred facility location to maximize the number of resource observation customers making use of the facility.

ORBIT SELECTION VS DISTRIBUTION OF POLAR PAYLOADS 1995-2000 LEO MISSIONS



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Mission Model

MISSION MODEL

The development of the mission model is grounded on the indicated basic constraints to assure it is sufficiently comprehensive and realistic for the purposes of the space station study.

MISSION MODEL

- ONLY SHUTTLE LAUNCHED MISSIONS
- USES KNOWN SCIENCE PRIORITIES
- BASED ON AN ASSUMED MISSION TRAFFIC VOLUME FOR:
  - MAJOR SCIENCE MISSIONS (E.G., SPACE TELESCOPE, AXAF)
  - MODERATE SCIENCE MISSIONS (E.G., SPACELAB-CLASS)
  - APPLICATIONS
  - COMMERCIAL
  - DoD

ASSUMED MISSION TRAFFIC

The primary constraint on the mission model takes the form of the defined limits on mission traffic for the indicated mission categories. Science and applications traffic is based on current and mid 80's expected launch rates. The commercial traffic volume is based on scenarios drawn from user specified requirements for communications, materials processing and remote sensing. DoD traffic is defined by an unclassified DoD mission model supplied by the DoD subtask.

ASSUMED MISSION TRAFFIC

PARAMETER	VALUE
MAJOR SCIENCE MISSIONS	1 PER YEAR, AVERAGE
MODERATE SCIENCE MISSIONS	7 PER YEAR, AVERAGE
OPERATIONAL APPLICATIONS LAUNCHES	
GOES-CLASS	1 PER 2 YEARS
NOAA-CLASS	1 PER 2 YEARS
LANDSAT-CLASS	1 PER 3 YEARS
COMMUNICATION SATELLITE LAUNCHES	
1990	17 (38K LBS)
1990-2000	CONTINUOUS CAPACITY GROWTH
2000	12 (65K LBS)
MATERIALS FACTORIES	
1990	7 TOTAL ON-ORBIT
2000	11 TOTAL ON-ORBIT
COMMERCIAL REMOTE SENSING VEHICLES	
1990	2 TOTAL ON-ORBIT
2000	5 TOTAL ON-ORBIT

MISSION MODEL STRUCTURE

On the basis of the orbit selection analysis, the mission model has been structured to divide missions into KSC launches (serviced by the low inclination space station) and VAFB launches (serviced by facilities at high inclinations). Within these categories the model is further divided according to the general accommodation needs of the missions.

MISSION MODEL STRUCTURE

TRW

MISSIONS

1. SCIENCE AND APPLICATIONS
2. COMMERCIAL
3. OPERATIONS
4. TECHNOLOGY DEVELOPMENT
5. DoD

KSC LAUNCHES (28.5°)

- ORBIT TRANSFER
  - EARTH ORBIT
  - PLANETARY
- FREE FLYER
- ATTACHED PAYLOAD (SS OR PLATFORM)
- MANNED LABORATORY

VAFB LAUNCHES (70° - 100°)

- EARTH-ORBIT TRANSFER
- NEAR POLAR
  - ATTACHED PAYLOAD (SS OR PLATFORM)
  - LEO FREE FLYER
- SUN SYNCHRONOUS
  - ATTACHED PAYLOAD (SS OR PLATFORM)
  - FREE FLYER
- MANNED LABORATORY

KSC LAUNCHES

The mission model is displayed in this and the following four charts. The model defines for each mission the year of launch, servicing events, and either the payload return or the mission end. Some missions feature multiple vehicles, payloads, and launch events as indicated. The schedule shows no finer resolution that one year. Returns following a launch in the same year imply six-month missions. Returns in the subsequent year indicate one-year missions. The missions in the model can be identified in terms of their acronym by using the mission list that is included in the charts immediately following the mission model.

KSC LAUNCHES

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YEAR

		PRE 1990	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1. CO-ORBIT FREE-FLYER	ST	L,R	L		S		R	L		S		S	
	GRO	L	S		E								
	SCDM								L		S		
	AIAF			L		S		S		S		S	
	EM			L		E		L		E		L	
	LDR					L		S		S		S	
	VLST										L		S
2. TRANSFER, EARTH ORBIT	ADVLBI											L	
	OPEN			L3									
	GOES		L		L		L		L		L		L
	GMS									L			
	CCP									L	L	L2	L3
	CCS-A		L8	L6	L4	L4	L3	L2	L2	L2	L1	L1	L1
	CCS-B		L5	L4	L3	L3	L4	L2,S	L2,S	S2	S2	S2	S2
	CCS-C		L4	L5	L6	L6	L7	L8	L6,S2	L2,S6	L5,S3	L7	L4,S2
	GPS		L4	L4	L4	L4	L4	L4	L4	L4	L4	L4	L4
	DODEG		L7	L6	L6	L11	L8	L3,S2	L4,S3	L2,S6	L2,S7	L3,S2	L3,S5
	DODEH		L1	L4	L3	L2	L2	L1	L2	L2	L2	L2	L2

LEGEND

L = LAUNCH
S = SERVICE
R = RETURN
E = END OF MISSION
L4, S4 = LAUNCH 4 VEHICLES, SERVICE 4 VEHICLES

KSC LAUNCHES (CONT)

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		YEAR											
		PRE 1990	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
3. TRANSFER, PLANETARY	MGO		L										
	LGO							L					
	MPN					L							
	TP				L								
	SP				L								
	UP						L						
	CR					L							
	AR									L			
	CSP						L		R				
	MSSR								L			R	
4. SP ATTACHED	SIRTF		L,R				L,R			L,R			
	STARLAB			L,R					L,R		L,R		L,R
	IRI												L
	CRE			L,R		L,R		L,R					
	CRO										L	R	
	LAMAR				L,R					L,R			
	XRO											L	R
5. MATERIALS PLATFORM	AMF-A	L5	L,S24	S24	S24	S24	L,S28	S28	S28	S28	S28	S28	S28
	AMF-B	L	S4	S4	S4	S4	L,S8	S8	S8	S8	S8	S8	S8
	AMF-C							L,S4	S4	S4	S4	S4	S4
	AMF-D										L,S4	S4	S4
	AMF-E											L,S4	S4

LEGEND
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L4, S4 = LAUNCH 4 VEHICLES, SERVICE 4 VEHICLES

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KSC LAUNCHES (CONT)

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		YEAR											
		PRE 1990	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
6.NSS ATTACHED	SOT		L,R		L,R								
	LDSN		L		S		R	L		S		S	
	ASD						L	R					
	CT-LEO			L,R				L,R					
	CSET			L,R		L,R		L,R		L,R		L,R	
	STPE		L	R,L	R,L	R,L	R,L	R,L2	R2,L2	R2,L2	R2,L2	R2,L2	R2,L2
	SATTD			L,R		L,R		L,R					
	OTVTD			L,R	L,R		L,R						
	LSSTD		L,R			L,R				L,R			
7.MANNED LAB	SM		L	S	S	S	S	S	S	S	S	S	S
	ASB			L	S	S	S	S	S	S	S	S	S
	GSB			L	S	S	S	S	S	S	S	S	S
	PBSA									L	R		
	NPL		L	S	S	S	S	S					
	INL-A			L	S	S	S	S	S	S	S	S	S
	INL-B							L	S	S	S	S	S

LEGEND
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- L4, S4 = LAUNCH 4 VEHICLES, SERVICE 4 VEHICLES

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VAFB LAUNCHES

		YEAR											
		PRE 1990	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1. LEO, NEAR-POLAR FREE-FLYERS	UARS	L	E										
	GP-B					L	E						
	EM					L		E		L		E	
	GNM						L		E				
	GIN								L			E	
2. TRANSFER, EARTH ORBIT	OPEN			L									
	TOPEX				L								
	DODVN		L	L	L	L	L	L	L	L	L2	L2	L2
3. LEO SUNSYNCH-RONOUS FREE-FLYERS	NOAA-A	L		L		L		L		L		L	
	NOAA-B		L		L		L		L		L		L
	LANDSAT	L	S	R,L		S	R,L		S		S		S
	RSS							L2	L2,S2	S4	S4	S4	S4
	DMSP-A	L		L		L		L		L		L	
	DMSP-B		L		L		L		L		L		L
	DODVL-A		L	L	L	L	L2	L	L2	L2	L2	L2	L2
	DODVL-B		L	L	L	L	L2	L2	L2	L2	L2	L	L2
	DODVL-C		L	L	L	L2	L2	L2	L2	L	L2	L2	L2
	DODVL-D		L	L	L	L2	L2	L2	L	L	L2	L2	L2
	ANNM-B		L		L,S	S	S	S	S	R,L,S	S	S	S
	STPV-B			L	R			L2	R2			L2	R2
	STPV-C					L	R			L2	R2		

LEGEND
L = LAUNCH
S = SERVICE
R = RETURN
E = END OF MISSION
L4, S4 = LAUNCH 4 VEHICLES, SERVICE 4 VEHICLES

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VAFB LAUNCHES (CONT)

YEAR

		PRE 1990	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
4. NEAR POLAR SP-ATTACHED PAYLOADS	DVLBI				L,R					L,R			
	SAMEI		L,R					L,R					
	LIDAR		L,R			L,R			L,R				
	OE			L,R			L,R			L,R			
	ME					L,R		L,R		L,R			
	SPPE			L,R								L,R	
	STO								L	R			
	WINDSAT								L		S		R
5. SUNSYNCHRONOUS SP-ATTACHED PAYLOADS	ESRM			L,R				L,R				L,R	
	RSP			L	S	S	L,S2	L,S3	S3	S3	S3	S3	S3
	STPV-A		L	R	L	R	L	R	L2	R2	L2	R2	R2,L2
	AMMH-A	L		L,S	S	R,L,S	S	R,L,S	S	S	S	R,L,S	S
6. MANNED LAB	STPV-A							L	S	S	S	L	S2

LEGEND
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- L4, S4 = LAUNCH 4 VEHICLES, SERVICE 4 VEHICLES

MISSION LIST

This and the following seven charts identify each of the missions in mission model. The missions are listed by category and the identifier or mnemonic used in the model. The full name and a brief objective is given for each mission.

MISSION LIST

CATEGORY	MNEMONIC	NAME	OBJECTIVE
ASTROPHYSICS: ASTRONOMY	ST	SPACE TELESCOPE	HIGH RESOLUTION OPTICAL, UV OBSERVATIONS
	SIRTF	SHUTTLE INFRARED TELESCOPE FACILITY	IR IMAGING FROM 2 TO 300 μm, EXTENDED MISSION DURATION
	STARLAB	STARLAB	WIDE-FIELD OPTICAL, UV OBSERVATIONS
	OVLBI	ORBITING VERY LONG BASELINE INTERFEROMETRY	EXTREMELY HIGH ANGULAR RESOLUTION RADIO SOURCE OBSERVATIONS
	LDR	LARGE DEPLOYABLE REFLECTOR	FAR-IR AND SUBMILLIMETER OBSERVATIONS
	TAT	100M THINNED APERTURE TELESCOPE	ADVANCED CAPABILITY OPTICAL, UV OBSERVATIONS
	IRI	INFRARED INTERFEROMETER	VERY HIGH ANGULAR RESOLUTION IR OBSERVATIONS
	VLST	VERY LARGE SPACE TELESCOPE	ADVANCED CAPABILITY OPTICAL, UV OBSERVATIONS
	AOVLBI	ADVANCED ORBITING VERY LONG BASELINE INTERFEROMETRY	ADVANCED VLBI OBSERVATIONS OF RADIO SOURCES
	COSMIC	COHERENT OPTICAL SYSTEM OF MODULAR IMAGING COLLECTORS	VERY HIGH ANGULAR RESOLUTION OPTICAL, UV OBSERVATIONS

MISSION LIST

CATEGORY	MNEMONIC	NAME	OBJECTIVE
ASTROPHYSICS: SOLAR PHYSICS	SOT	SOLAR OPTICAL TELESCOPE	OPTICAL AND UV IMAGING OF THE SUN
	LDSM	LONG DURATION SOLAR MONITORING	LONG DURATION OBSERVATIONS OF SOLAR OUTPUT
	ASO	ADVANCED SOLAR OBSERVATORY	SIMULTANEOUS UV, OPTICAL, X-RAY, GAMMA-RAY SOLAR OBSERVATIONS
	SCDM	SOLAR CORONA DYNAMICS MISSION	OBSERVE STRUCTURE, DYNAMICS OF SOLAR CORONA
	STARPROBE	STAR PROBE	OBSERVE IN VICINITY OF THE SUN CORONA, SOLAR WIND, GRAVITY FIELD, SOLAR INTERIOR
	P/O-F	PINHOLE/OCCULTER FACILITY	OBSERVE SOLAR HARD X-RAYS
ASTROPHYSICS: HIGH ENERGY OBSERVATIONS	GRO	GAMMA RAY OBSERVATORY	HIGH SENSITIVITY, ENERGY-RESOLUTION GAMMA-RAY ASTRONOMY
	AXAF	ADVANCED X-RAY ASTROPHYSICS FACILITY	LONG TERM HIGH RESOLUTION X-RAY IMAGING
	CRE	COSMIC-RAY EXPERIMENTS	STUDY COSMIC-RAY COMPOSITION, ENERGY SPECTRA
	CRO	COSMIC-RAY OBSERVATORY	LONG DURATION, MULTI-INSTRUMENT COSMIC RAY OBSERVATIONS
	LAMAR	LARGE AREA MODULAR ARRAY OF REFLECTORS	FULL SKY SURVEY OF X-RAY SOURCES
	XRO	X-RAY OBSERVATORY	BROAD-BAND X-RAY OBSERVATIONS OF GALACTIC PHENOMENA
	GWI	GRAVITY WAVE INTERFEROMETER	SEARCH FOR GRAVITATIONAL RADIATION

MISSION LIST

CATEGORY	MNEMONIC	NAME	OBJECTIVE
ASTROPHYSICS: EXPLORER MISSIONS	EM	EXPLORER MISSIONS	SERIES OF LIMITED OBJECTIVE SMALLER SCALE ASTROPHYSICS INVESTIGATIONS
LIFE SCIENCE	SM	SPACE MEDICINE	STUDY OF LONG TERM SPACE FLIGHT EFFECTS ON MAN
	ASB	ANIMAL SPACE BIOLOGY	DETERMINE LONG TERM SPACE FLIGHT EFFECTS, REMEDIES USING ANIMAL SUBJECTS
	GSB	GENERAL SPACE BIOLOGY	STUDY ANIMAL, PLANT ORGANISM BIOLOGICAL RESPONSES IN SPACE
	PSBA	PLANETARY SAMPLE BIOLOGICAL ANALYSIS	ANALYZE AND QUARANTINE PLANETARY BIOLOGICAL SAMPLES
	SER	SPACE ECOLOGY RESEARCH	STUDY CLOSED CYCLE ECOLOGICAL SYSTEMS FOR LONG DURATION, REMOTE MANNED SPACE FLIGHT
	ALST	ADVANCED LIFE SUPPORT TECHNOLOGY	DEVELOP AND TEST ADVANCED LIFE SUPPORT SYSTEMS, IN SPACE

MISSION LIST

CATEGORY	MNEMONIC	NAME	OBJECTIVE
EARTH AND PLANETARY EXPLORATION: EARTH EXPLORATION	SAMEX	SHUTTLE ACTIVE MICROWAVE EXPERIMENT	MULTIBAND IMAGING RADAR OBSERVATIONS
	GMM	GRAVITY FIELD MONITORING MISSION	DEFINITION, MONITORING OF EARTH'S GEOID, GRAVITY FIELD
	ESRM	EARTH SCIENCES RESEARCH MISSION	ACQUIRE SPECTRUM-WIDE MULTIBAND DATA FOR EARTH RESOURCES, RESEARCH IN BIOMASS, LAND USE, GEOSCIENCES
	GIM	GEOPHYSICAL INVESTIGATION MISSION	MAP EARTH'S MAGNETIC FIELD, CRUSTAL MAGNETIC TIME VARIATION
EARTH AND PLANETARY EXPLORATION: PLANETARY EXPLORATION	MGO	MARS GEOSCIENCE ORBITER	DETERMINE MARS SURFACE COMPOSITION, TOPOGRAPHY, GRAVITY
	LGO	LUNAR GEOSCIENCE ORBITER	DETERMINE LUNAR SURFACE COMPOSITION, TOPOGRAPHY, GRAVITY
	MAO	MARS AERONOMY ORBITER	DETERMINE UPPER ATMOSPHERE SOLAR WIND INTERACTION, MAGNETIC FIELD
	MPN	MARS PENETRATOR NETWORK	DETERMINE BULK COMPOSITION, STRUCTURE WEATHER
	VP	VENUS PROBE	MEASURE VENUS ATMOSPHERIC COMPOSITION
	TP	TITAN PROBE	MEASURE TITAN ATMOSPHERIC COMPOSITION
	SP	SATURN PROBE	MEASURE SATURN ATMOSPHERIC COMPOSITION
	UP	URANUS PROBE	MEASURE URANUS ATMOSPHERIC COMPOSITION
	SO	SATURN ORBITER	ORBIT SATURN, EXPLORE SATELLITES
	CR	COMET RENDEZVOUS	ANALYZE COMET NUCLEUS, ATMOSPHERE, SOLAR WIND INTERACTION

MISSION LIST

CATEGORY	MNEMONIC	NAME	OBJECTIVE
EARTH AND PLANETARY EXPLORATION: PLANETARY EXPLORATION (CONTINUED)	AR	ASTEROID RENDEZVOUS	DETERMINE COMPOSITION, SURFACE AND INTERNAL CHARACTERISTICS OF ASTEROIDS
	CPSR	COMET PLASMATIZED SAMPLE RETURN	DETERMINE COMPOSITION, PHYSICAL STATE OF COMET NUCLEUS
	CSR	COMET SAMPLE RETURN	DETERMINE COMPOSITION PHYSICAL STATE OF COMET NUCLEUS
	ASR	ASTEROID SAMPLE RETURN	DETERMINE ASTEROID COMPOSITION AND STRUCTURE
	MSSR	MARS SURFACE SAMPLE RETURN	DETERMINE CHEMICAL, MINERAL, BIOLOGICAL CHARACTERISTICS OF MARS SURFACE
	SSSO	SOLAR SYSTEM SPACE OBSERVATORY	CONDUCT, IN EARTH ORBIT LONG TERM OBSERVATION OF SOLAR SYSTEM BODIES
	IPD	INTERPLANETARY DUST COLLECTION MISSION	DETERMINE INTERPLANETARY DUST CHARACTERISTICS
	VL	VENUS LANDER	DETERMINE CHEMICAL, MINERALOGICAL COMPOSITION OF VENUS SURFACE, VENUS SEISMIC ACTIVITY
ENVIRONMENTAL OBSERVATIONS	OPEN	ORIGIN OF PLASMAS IN EARTH NEIGHBORHOOD	STUDY HELIOSPHERE MAGNETOSPHERE IONOSPHERE ENERGY INTERACTIONS
	UARS	UPPER ATMOSPHERE RESEARCH SATELLITE	STUDY RADIATION, CHEMISTRY, DYNAMICS OF STRATOSPHERE, MEOSPHERE, THERMOSPHERE
	TOPEX	OCEAN TOPOGRAPHY EXPERIMENT	ADVANCE UNDERSTANDING OF GLOBAL OCEANIC CIRCULATION

MISSION LIST

CATEGORY	MNEMONIC	NAME	OBJECTIVE
ENVIRONMENTAL OBSERVATIONS	OE	OCEAN EXPERIMENTS	OBSERVATION OF MULTIPLE OCEAN PHENOMENA
	ME	METEOROLOGICAL EXPERIMENTS	OBSERVATION OF MULTIPLE ATMOSPHERIC PHENOMENA
	SPPE	SPACE PLASMA PHYSICS EXPERIMENTS	OBSERVATION OF SPACE PLASMA PHYSICS PHENOMENA USING ACTIVE AND PASSIVE METHODS
	STO	SOLAR TERRESTRIAL OBSERVATORY	STUDY PHYSICAL PROCESSES, INTERRELATIONSHIPS OF: SOLAR ATMOSPHERE, INTERPLANETARY MEDIUM, MAGNETOSPHERE, EARTH ATMOSPHERE
	LIDAR	LIDAR FACILITY	SOUNDING OF TROPOSPHERE
	WINDSAT	WINDSAT	MEASURE WIND VECTOR PROFILES USING DOPPLER LIDAR
	PPS	PLASMA PHYSICS SUBSATELLITE	OBSERVE SPACE PLASMA PHENOMENA IN VICINITY OF LOW EARTH ORBIT
	GMS	GEOSYNCHRONOUS MICROWAVE SOUNDING MISSION	ALL WEATHER MONITORING OF ATMOSPHERIC TEMPERATURE, STRUCTURE, MOISTURE
APPLICATIONS: COMMUNICATIONS	CT-LEO	COMMUNICATIONS TECHNOLOGY – LOW EARTH ORBIT	TEST COMMUNICATIONS SYSTEM ELEMENTS (E.G., ANTENNAS) IN LOW EARTH ORBIT
	CT-GEO	COMMUNICATIONS TECHNOLOGY – GEOSYNCHRONOUS ORBIT	TEST COMMUNICATIONS SYSTEM IN GEOSYNCHRONOUS ORBIT
	ODSRS	ORBITING DEEP SPACE RELAY STATION	PROVIDE DEEP SPACE TRACKING AND COMMUNICATIONS SUPPORT OF DEEP SPACE MISSIONS

MISSION LIST

CATEGORY	MNEMONIC	NAME	OBJECTIVE
APPLICATIONS: MATERIALS PROCESSING	MPL	MATERIALS PROCESSING LABORATORY	PROVIDE FACILITY FOR SHIRTSLEEVE – ENVIRONMENT MATERIALS RESEARCH
	AMEV	AUTOMATED MATERIALS EXPERIMENT VEHICLE	PROVIDE AUTOMATED VEHICLE TO CARRY MATERIALS RESEARCH EXPERIMENTS
APPLICATIONS: METEOROLOGY	GOES	GEOSTATIONARY OPERATIONAL ENVIRONMENTAL SATELLITE	GEOSYNCHRONOUS ORBIT ATMOSPHERIC SOUNDING OF ATMOSPHERE FOR WEATHER PREDICTION
APPLICATIONS: LAND OBSERVATIONS	LANDSAT	LANDSAT 4/5 REFLIGHT	OPERATIONAL LAND REMOTE SENSING
	RADARSAT	RADARSAT	IMAGING RADAR OBSERVATION OF OCEAN AND ICE STATE
COMMERCIAL: MATERIALS PROCESSING	IML	INDUSTRIAL MATERIALS LABORATORY	PROVIDE FACILITY FOR SHIRTSLEEVE ENVIRONMENTAL INDUSTRIAL MATERIALS RESEARCH
	AMF	AUTOMATED MATERIALS FACTORY	COMMERCIAL MATERIALS PRODUCTION
COMMERCIAL: COMMUNICATIONS	CSET	COMMERCIAL SYSTEM ELEMENT TEST	TEST COMMUNICATIONS SYSTEMS ELEMENTS
	CCS	COMMERCIAL COMMUNICATIONS SATELLITE	GENERIC GEOSYNCHRONOUS ORBIT COMMUNICATIONS SATELLITE
	CCP	COMMERCIAL COMMUNICATIONS PLATFORM	GENERIC LARGE GEOSYNCHRONOUS ORBIT COMMUNICATIONS SATELLITE
COMMERCIAL: REMOTE SENSING	RSS	REMOTE SENSING SATELLITE	PROVIDE COMMERCIAL EARTH AND OCEAN REMOTE SENSING DATA
	RSP	REMOTE SENSING PAYLOAD	PROVIDE COMMERCIAL EARTH AND REMOTE SENSING DATA – PLATFORM IMPLEMENTATION

MISSION LIST

CATEGORY	MNEMONIC	NAME	OBJECTIVE
TECHNOLOGY DEVELOPMENT	SATTD	SERVICING, ASSEMBLY, AND TEST TECHNOLOGY DEVELOPMENT	GENERIC MISSION TO DEVELOP ON-ORBIT SATELLITE SERVICING, ASSEMBLY AND TEST TECHNOLOGIES
	OTVTD	ORBIT TRANSFER VEHICLE TECHNOLOGY DEVELOPMENT	GENERIC MISSION TO DEVELOP ORBIT TRANSFER VEHICLE AND RELATED ON-ORBIT SERVICING TECHNOLOGIES
	LSSTD	LARGE SPACE STRUCTURE TECHNOLOGY DEVELOPMENT	GENERIC MISSION TO DEVELOP LARGE SPACE STRUCTURE ASSEMBLY, TEST, ALIGNMENT, CONTROL AND CALIBRATION TECHNOLOGIES
DoD MISSIONS	GPS	GLOBAL POSITIONING SYSTEM	PROVIDE SPACE BASED GLOBAL POSITIONING
	DMSP	DEFENSE METEOROLOGY SATELLITE PROGRAM	PROVIDE MILITARY GLOBAL METEOROLOGICAL COVERAGE
	STPE	SPACE TEST PROGRAM – ELS LAUNCH	SUPPORT DoD RDT&E TESTING FROM ELS
	STPV	SPACE TEST PROGRAM – VLS LAUNCH	SUPPORT DoD RDT&E TESTING FROM VLS
	DODEG	DoD ELS LAUNCHES TO MID INCLINATIONS AND GEO	DELIVERY/SERVICING OF PAYLOADS FROM ELS TO GEO AND EQUIVALENT ORBITS
	DODEH	DoD ELS LAUNCHES, HEO ORBITS	DELIVERY/SERVICING OF PAYLOADS FROM ELS TO HIGH ENERGY ORBITS
	DODVH	DoD VLS LAUNCHES, HEO ORBITS	DELIVERY/SERVICING OF PAYLOADS FROM VLS TO HIGH ENERGY ORBITS
	DODVL	DoD VLS LAUNCHES, LEO ORBITS	DELIVERY/SERVICING OF PAYLOADS FROM VLS TO LOW EARTH ORBITS
	AMWM	DoD ADVANCED METEOROLOGY WORLD MONITOR	PROVIDE ADVANCED ENVIRONMENTAL MONITORING AND GENERAL MONITORING ON A GLOBAL BASIS

Key Missions

KEY SPACE STATION MISSIONS

Key missions are selected from the mission model to illustrate the important benefits of the space station. In this instance, a key mission has both a high priority or likelihood of being flown and also a high payoff in terms of the benefits obtained from the space station.

These science missions show the potential of the space station architecture in providing both unique, advanced capabilities and opportunities for more flexible, economic missions.

KEY SPACE STATION MISSIONS

KEY MISSIONS ⟺ HIGH PROBABILITY AND HIGH PAYOFF

CATEGORY	GENERIC MISSION (EXAMPLES)	PAYOFF
SCIENCE AND APPLICATIONS	PERMANENT SCIENCE FACILITIES (ST, AXAF)	MAXIMUM RETURN ON SCIENCE INVESTMENT
	ASSEMBLED INSTRUMENTS (LDR)	REVOLUTIONIZED INSTRUMENT CAPABILITY
	MULTIFLIGHT PAYLOADS (SOT, SIRTF)	LOWER COST, LONGER DURATION SCIENCE MISSIONS
	OBSERVATORY PLATFORMS (ASO, STO)	INTENSITVE INTERDISCIPLINARY INVESTIGATIONS
	MANNED LABORATORIES	UNIQUE LONG-DURATION IN SITU EXPERIMENTS

KEY SPACE STATION MISSIONS (Continued)

Important commercial missions include communication satellites, an industrial laboratory and remote sensing. The industrial materials lab is included because it clearly depends on the availability of the space station and there is a strong demand for such a facility for developing commercially viable products. Once profitable materials factories have been established it is expected that the demand for this facility will be even greater as corporations endeavor to establish other space manufactured products.

Some of the identified key missions will be discussed in more detail in the following. The economic benefits to the commercial communications and geosynchronous DoD missions will be developed in considerable detail in the upcoming benefits section of this briefing.

KEY SPACE STATION MISSIONS (CONT)

CATEGORY	GENERIC MISSION (EXAMPLES)	PAYOFF
COMMERCIAL	COMMUNICATIONS SATELLITES	REDUCED COST OF TRANSPORTING AND MAINTAINING ASSETS
	INDUSTRIAL LABORATORY	EXPEDITES AND MAXIMIZES POTENTIAL OF MATERIALS PROCESSING IN SPACE
	REMOTE SENSING	SPACE STATION ECONOMIES = PROFITABLE OPERATIONS
TECHNOLOGY	SATELLITE SERVICING, ASSEMBLY AND TEST; OTV DEVELOPMENT AND SERVICING	TECHNOLOGIES NECESSARY TO REALIZE FULL POTENTIAL OF SS
	LARGE ANTENNA ASSEMBLY AND TEST	MOBILE COMMUNICATIONS; SURVEILLANCE/ SENSING AT GSO
DoD	GEOSYNCHRONOUS MISSIONS	REDUCED COST OF TRANSPORTING AND MAINTAINING ASSETS

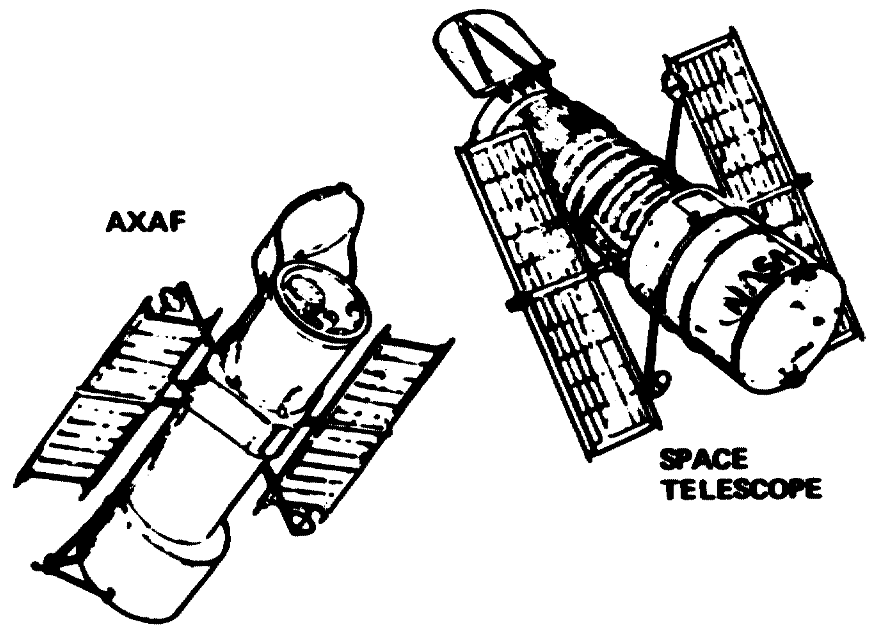
PERMANENT SCIENCE FACILITIES

The value of a space station to large science fa .lities such as Space Telescope and AXAF is reviewed. The space station provides the opportunity to make these truly permanent science facilities similar to today's ground based astronomy and astrophysics observatories.

PERMANENT SCIENCE FACILITIES

MISSION OBJECTIVES:

- SPACE TELESCOPE — LONG DURATION OPTICAL, UV OBSERVATORY
- AXAF — LONG DURATION X-RAY OBSERVATORY



SPACE STATION SCENARIO:

- RELIEVE SHUTTLE OF MAINTENANCE ROLE RETRIEVE, SERVICE, REPLACE
- ACCOMMODATE ST SECOND FLIGHT; AXAF INITIAL FLIGHT
- GOAL OF PERMANENTLY MAINTAINED ON-ORBIT OBSERVATORIES
- POSSIBLY CHANGE-OUT MIRRORS ON ORBIT, CALIBRATE SYSTEM

ANTICIPATED PAYOFFS:

- INCREASED UTILITY OF OBSERVATORIES THROUGH LONGER ON-ORBIT LIFE
- LOWERS COST OF MAINTAINING ON-ORBIT CAPABILITY
- ESTABLISHES SS CAPABILITY FOR SERVICING, MAINTAINING LARGE FREE FLYERS

ASSEMBLED INSTRUMENTS

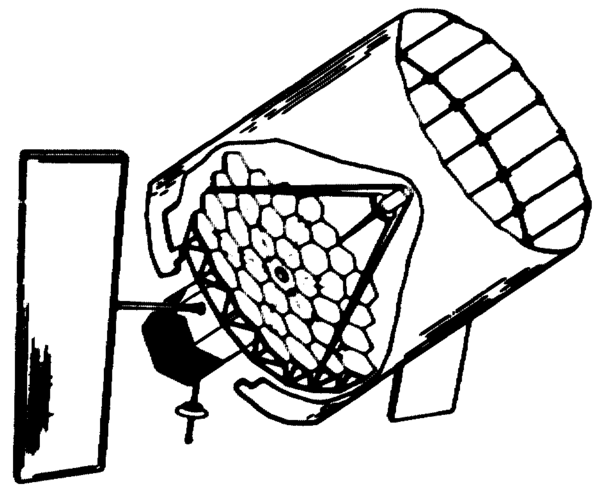
A space station provides the opportunity for greatly enhanced instrument capabilities that are either impossible or uneconomic using currently available shuttle deployment practices. The LDR provides one high science priority example of this type of science facility.

ASSEMBLED INSTRUMENTS

LARGE DEPLOYABLE REFLECTOR

MISSION OBJECTIVES:

- HIGH RESOLUTION FAR-IR, SUBMILLIMETER ASTRONOMY
- 10–30M MULTI-ELEMENT REFLECTOR TELESCOPE
- DEPLOYMENT OR CONSTRUCTION IN SPACE



SPACE STATION SCENARIO:

- DEPLOY AND/OR CONSTRUCT REFLECTOR
- CALIBRATE OPTICS
- MOUNT TO SPACE PLATFORM OR DEPLOY AS FREE FLYER
- SUBSEQUENT SERVICING
- POSSIBLE AUGMENTATION TO GREATER DIAMETER

ANTICIPATED PAYOFFS:

- ENHANCES HIGH SCIENCE PRIORITY MISSION (SHUTTLE LIMITED TO < 10 METERS)
- MORE ECONOMIC DESIGN, SIMPLIFIED DEPLOYMENT
- ESTABLISHES CAPABILITY FOR FUTURE APPLICATION (ANTENNAS, INTERFEROMETERS)

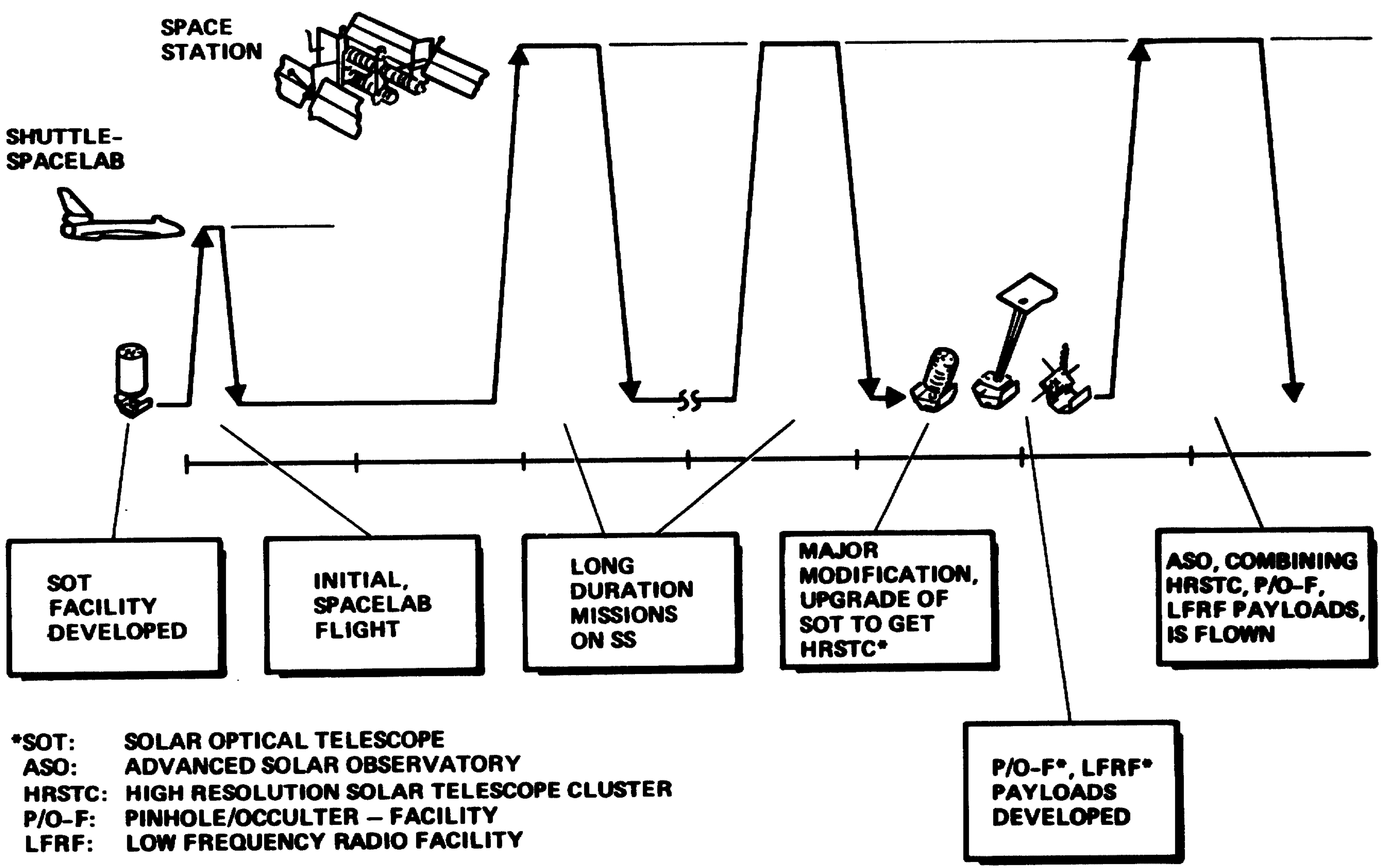
MULTI-FLIGHT PAYLOADS AND OBSERVATORY PLATFORMS
SOT AND ASO EXAMPLE SCENARIO

The space station and space platform provide an extention of the reuseable space instrument concept first introduced with Shuttle-Spacelab. The scenario depicts the evolution of one payload, SOT from 1) initially, a Spacelab instrument through 2) longer duration space station flights and ultimately, after upgrading, 3) incorporation into an interdisciplinary observatory platform, ASO.

Program Management Division
TRW Space & Technology Group

MULTI-FLIGHT PAYLOADS AND OBSERVATORY PLATFORMS SOT* AND ASO* EXAMPLE SCENARIO

TRW



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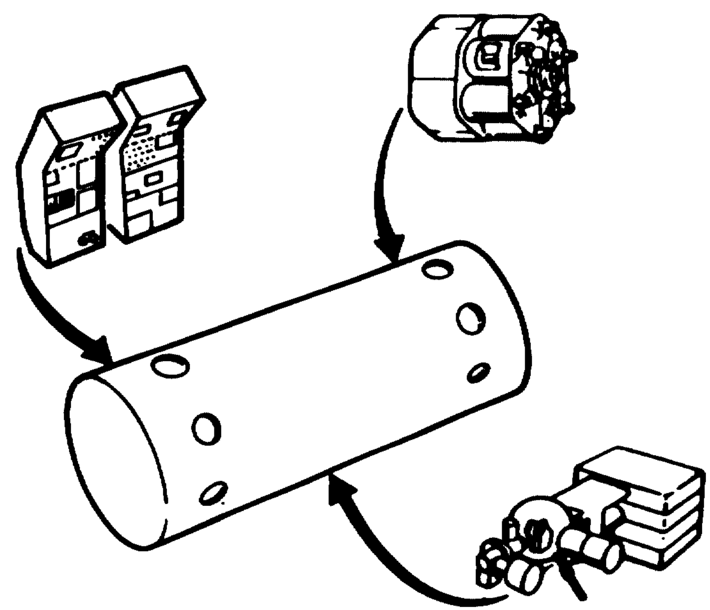
*SOT: SOLAR OPTICAL TELESCOPE
ASO: ADVANCED SOLAR OBSERVATORY
HRSTC: HIGH RESOLUTION SOLAR TELESCOPE CLUSTER
P/O-F: PINHOLE/OCCULTER – FACILITY
LFRF: LOW FREQUENCY RADIO FACILITY

INDUSTRIAL MATERIALS RESEARCH LABORATORY

The concept of an industrial materials research laboratory is introduced. This facility would provide industry representatives hands-on access to space materials experiments. It would enhance the prospects for finding profitable commercial processes and would provide unique conditions to investigate problems associated with on-earth materials processing.

INDUSTRIAL MATERIALS RESEARCH MANNED LABORATORY



MISSION OBJECTIVES:

- LOW COST SPACE RESEARCH IN COMMERCIAL MATERIALS/PROCESSES
- QUALITY CONTROL TESTING OF MATERIALS PRODUCTION

SPACE STATION SCENARIO:

- PERMANENTLY ATTACHED LABORATORY
- GENERAL PURPOSE INSTRUMENTS PROVIDED BY INDUSTRIAL CONSORTIUM
- PROCESSORS PROVIDED BY INVESTIGATORS
- INITIAL LAB MULTIPURPOSE; LATER, SEPARATE FLUIDS AND METALS LABS

ANTICIPATED PAYOFFS:

- COST AND FLEXIBILITY OF RESEARCH COMMENSURATE WITH COMMERCIAL R/D
- ALLOWS FAMILIAR MANNED EXPERIMENTATION WITH FLEXIBILITY IN AUTOMATION
- SAVINGS IN OPERATIONS AND TRANSPORTATION THROUGH IN PROCESS QUALITY CONTROL
- LONGER MISSION DURATIONS THAN WITH STS

Integrated, Phased Requirements

PHASED MISSION REQUIREMENTS

FACILITIES AT 28.5° INCLINATION, LOW EARTH ORBIT

The mission requirements on facilities at 28.5° inclination are given in this and the following chart. Requirements are specified in terms of user category and time phase. The support of free-flying vehicles is specified in terms of the functional capabilities of the TMS, general satellite servicing, assembly of vehicles and instruments, and transportation to higher energy orbits using a returnable orbit transfer vehicle (ROTV). Note, the use of the arrow indicates that the requirement continues from one phase to the next.

Payloads that are attached to a space platform require orbital resources specified in terms of number of payload attachment ports, viewing access, payload power, data and communication capacities. The indicated power and data requirements are totals that represent the need of all payloads on orbit at one time and attached to the platform, or platforms.

PHASED MISSION REQUIREMENTS FACILITIES AT 28.5^{0} INCLINATION, LOW EARTH ORBIT,

MISSION CATEGORY	REQUIREMENTS		
	1990-1991	1995	2000
FREE FLYING VEHICLES	TMS SATELLITE SERVICE EARLY ASSEMBLY CAPABILITY	→ → → RETURNABLE OTV	→ → LARGE SCALE ASSEMBLY →
SPACE PLATFORM ATTACHED PAYLOADS PORTS VIEWING POWER, KW DATA, MBPS PEAK AVERAGE	2 CELESTIAL 3.4 7.1 1.5	2 CELESTIAL 4.5 7.1 1.5	5 CELESTIAL 13 10 2.9

PHASED MISSION REQUIREMENTS

FACILITIES AT 28.5° INCLINATION, LOW EARTH ORBIT (CONTINUED)

The requirements on facilities at 28:5° are given for space station attached payloads and for payloads housed within a manned laboratory. The requirements for the space station attached payloads are specified in the same way as those for the space platform on the preceding chart.

In addition to power and data, the manned laboratory requirements specify laboratory volume. For reference, the volume is also expressed in terms of number of standard 19" racks. An assumed $2M^3$ per rack volume allows for both equipment and manned working space.

PHASED MISSION REQUIREMENTS FACILITIES AT 28.5^{0} INCLINATION, LOW EARTH ORBIT, CONTINUED

MISSION CATEGORY	REQUIREMENTS		
	1990-1991	1995	2000
SPACE STATION ATTACHED PAYLOADS			
PORTS	4	6	6
VIEWING	SOLAR, CELESTIAL, EARTH	→	→
POWER, KW	9	9	9
DATA, MBPS			
PEAK	60	60	60
AVERAGE	25	25	25
MANNED LABORATORY PAYLOADS			
VOL., M^3	36	56	56
EQUIV. RACKS	18	26	26
POWER, KW	6	13	13
DATA, MBPS	5	5	5

PHASED MISSION REQUIREMENTS
FACILITIES AT 97° INCLINATION, SUN SYNCHRONOUS ORBIT

The mission requirements are given for either space station or space platform facilities at the sun synchronous orbital location with a 0900 hour equatorial crossing. This orbit was determined in the previously mentioned orbit selection trade. The types of requirements for the 97° inclination orbit are generally the same as those for the 28.5° inclination orbit. The mission model at 97° inclination indicates no need, however, for large facility or vehicle assembly and no need for special orbit transfer vehicles. Attached payload data requirements are considerably larger than those for missions at the lower inclinations, whereas at the high inclination, only limited, DoD related, manned lab facilities are needed.

PHASED MISSION REQUIREMENTS FACILITIES AT 97° INCLINATION, SUN SYNCHRONOUS ORBIT

MISSION CATEGORY	REQUIREMENTS		
	1990-1991	1995	2000
FREE FLYING VEHICLES	TMS SATELLITE SERVICE	→ →	→ →
SPACE PLATFORM OR SPACE STATION ATTACHED PAYLOADS			
PORTS	3	5	5
VIEWING	CELESTIAL, EARTH	CELESTIAL, EARTH, SOLAR	→
POWER, KW	12	31	31
DATA, MBPS			
PEAK	300-600	300-750	300-750
AVERAGE	132	162	162
MANNED LABORATORY PAYLOADS			
VOL, M^3	8	8	12
EQUIV. RACKS	4	4	6
POWER	2	2	2

ADOPTED SPACE STATION CREW SIZE REQUIREMENTS

The indicated requirements are based on the evaluations in the previous chart. The initial SS at 28.5° inclination will require only 3 members since initially the lab facilities are not available and hence, payload specialists are not required. These are added in the following year. Subsequent increases in crew size are due to added space station capacity for both servicing and direct payload operations and experiment evaluation.

ADOPTED SPACE STATION CREW SIZE REQUIREMENTS

	1990	1991	1995	2000
28.5° INCLINATION LEO SS	3*	5	8	10
97° INCLINATION LEO SS			3	3

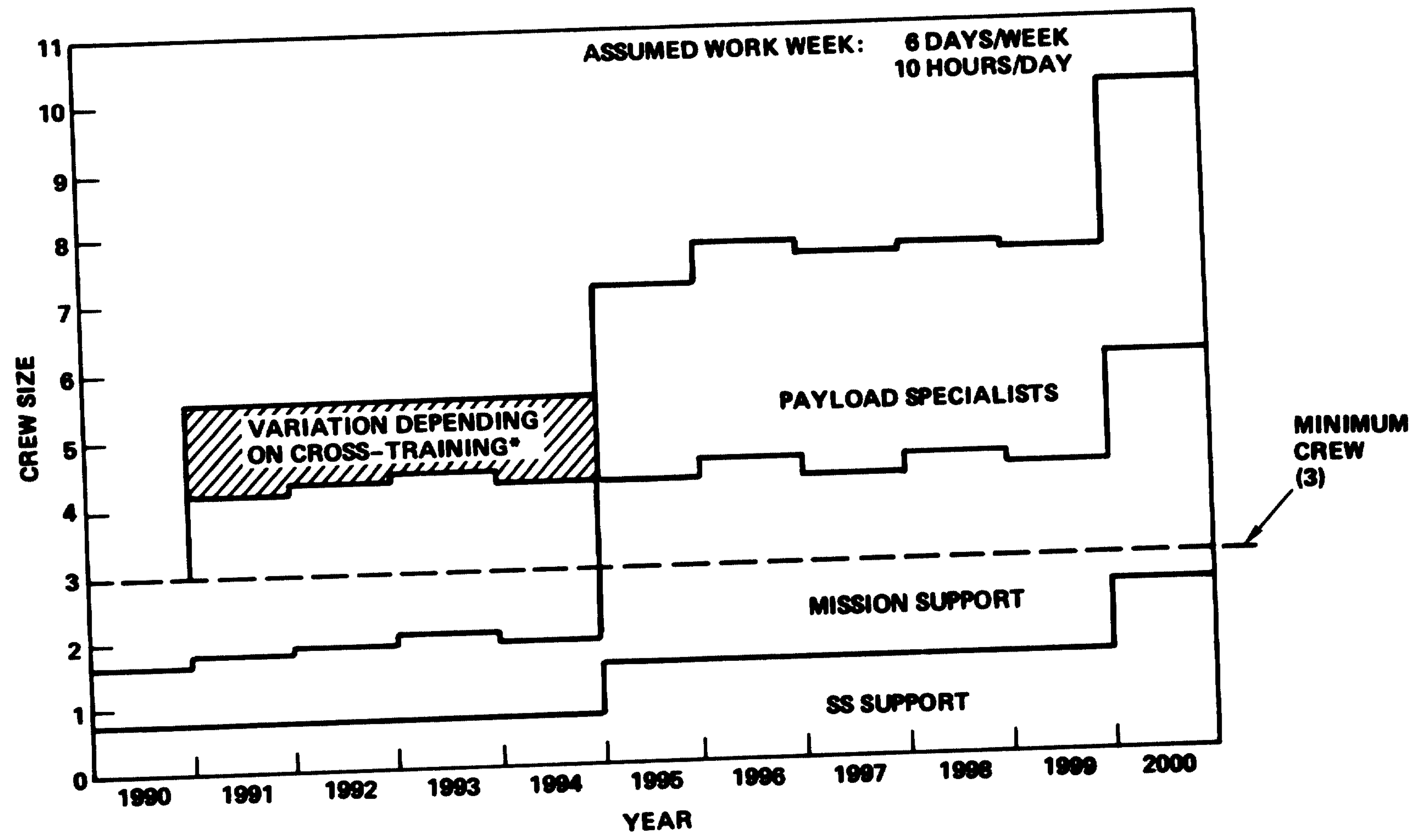
* REFLECTS SS CAPABILITY BUILD-UP

CREW REQUIREMENTS FOR 28.5° INCLINATION LOW EARTH ORBIT SPACE STATION

The space station crew effort has been broken down into three categories: SS support, mission support and payload specialists. SS support includes all activities necessary to maintain and operate the SS. Mission support incorporates the requirements for handling all mission payloads, stages and hardware serviced by the space station. It also includes maintenance of the space-based TMS and returnable OTV's. Payloads specialists are specially trained personnel that operate the payload equipment either housed within the manned lab, externally attached to the space station or possibly flying near-by as a co-orbiting free-flyer.

The chart shows crew size estimates for these categories given as a function of time. The estimates are based on Skylab experience, recent servicing studies and a breakdown of tasks derived from the mission model. As shown on the chart, the crew requirement in the early period varies between 4 and 5.5 members depending if the payload specialist requirement is added to the support requirements or, alternately, to what is believed to be the minimum operations crew size of three members. The resulting early SS requirement, either 4 or 5, depends on the amount of cross training desired.

CREW REQUIREMENTS FOR 28.5^0 INCLINATION LOW EARTH ORBIT SPACE STATION



MISSION MODEL TRAFFIC SUMMARY

This table summarizes the payload shuttle-launch requirements for the space station model. The mission payload weights have been augmented by propulsion weight to arrive at the total launch requirement. The totals are for missions-only and do not include STS cargo required to build or maintain space station facilities. The requirements for KSC and VAFB launches are converted into estimated numbers of STS launches by dividing by assumed performance capabilities (75 Klbs and 32.4 Klbs for KSC and VAFB, respectively) and load factor.

MISSION MODEL TRAFFIC SUMMARY

	YEAR										
	90	91	92	93	94	95	96	97	98	99	00
KSC LAUNCH WEIGHT (10^3 LBS)											
FREE FLYERS*	744	701	764	1005	842	668	847	1003	930	770	906
ATTACHED	74	30	110	13	66	81	29	116	42	46	95
TOTAL	818	731	875	1018	908	749	876	1119	972	816	.1001
VAFB LAUNCH WEIGHT (10^3 LBS)											
FREE FLYERS*	48	64	51	75	61	79	79	73	97	106	95
ATTACHED	18	26	17	22	9	31	51	15	7	18	7
TOTAL	66	90	68	97	70	110	130	88	104	124	102
EQUIVALENT STS LAUNCHES (80% LOAD)											
KSC	14	12	15	17	15	13	15	19	17	14	17
VAFB	3	4	3	4	3	5	5	4	4	5	4

*INCLUDING PROPULSION STAGES

SATELLITE SERVICING EVENTS

Servicing events in the mission model are summarized for the 28.5° inclination and 97° inclination orbits. The events at 28.5° are broken out between free flyers and materials processing; the materials processing events reflect an assumed 90-day servicing cycle for each materials factory in the model. The free flyer service events include servicing of geosynchronous satellites, an activity that begins in 1995.

SATELLITE SERVICING EVENTS

FACILITY INCLINATION		YEAR 90	91	92	93	94	95	96	97	98	99	00
28.5°	FREE-FLYER	1	0	1	1	1	5	6	19	12	7	10
	MATERIALS	28	28	28	28	36	40	40	40	44	48	48
97°		1	1	2	3	2	2	4	4	5	5	3

DATA MANAGEMENT REQUIREMENTS

Preliminary and approximate space station data management requirements are derived using the integrated mission requirements and the space station study scenario assumptions. These requirements are given in the chart according to the format requested by B. Pritchard in a February 1983 letter to the space station study managers. It should be emphasized that these data are very preliminary and require additional trade analysis prior to further refinement. One central issue that requires resolution involves the question of ground vs. space station-based computing capability. Many of the requirements parameters are directly affected including: real time coverage (R/T TT&C), on board computing, SS-ground computing, sequence storage, and manned control.

DATA MANAGEMENT REQUIREMENTS (1995)

PARAMETER	FACILITY/INCLINATION			
	$SS/28.5^{o}$	$SP/28.5^{o}$	$SS/97^{o}$	$SP/97^{o}$
1. PER ORBIT DATA VOL, GB	194	8	875	875
2. R/T TT&C, PERCENT FACILITY CONTROL PAYLOAD CONTROL	 ~ 0 $0 \rightarrow 100$	 ~ 0 $0 \rightarrow 100$	 ~ 0 $0 \rightarrow 100$	 ~ 0 $0 \rightarrow 100$
3. ON BOARD COMPUTING FACILITY CONTROL PAYLOAD SUPPORT	✓ (MANNED LAB)	✓	✓ (MANNED LAB)	✓
4. SS-GROUND COMPUTING TRAFFIC, MBPS	36	1.5	162	162
5. SEQUENCE STORAGE	TBS	TBS	TBS	TBS
6. MANNED CONTROL	ON BOARD, R/T TT&C	R/T TT&C	ON BOARD, R/T TT&C	R/T TT&C
7. TELECONFERENCING SUPPORT	VOICE, MULITCHANNEL TV	NA	VOICE, MULTICHANNEL TV	NA
8. ANALOG DATA	ON BOARD A/D	ON BOARD A/D	ON BOARD A/D	ON BOARD A/D
9. SECURITY NEEDS, MBPS DoD COMMERCIAL	 20 MINIMAL	NONE	 72 45	 72 45

REQUIREMENTS SOURCES

The following five charts provide traceability for the phased mission requirements on the space station facilities. Each facility resource requirement is identified with the corresponding driving missions from the mission model and their individual resource requirements.

REQUIREMENTS SOURCES
28.5° INCLINATION FACILITIES

REQUIREMENT	PHASE/SOURCE		
	1990-1991	1995	2000
TMS SATELLITE SERVICE INITIAL ASSEMBLY LARGE SCALE ASSEMBLY RETURNABLE OTV	ST, AXAF ST, AXAF LDR	CCS, DODEG MSSR CCS, DODEG	VLST, IRI
SP POWER, 3.4KW 4.7KW 13KW	LAMAR	SIRTF (1.3) LAMAR (3.4)	CRO (3) XRO (10)
SP PEAK DATA, 7.1 MBPS	STARLAB (7) CRE (0.1)		
SP AVERAGE DATA, 1.5MBPS 2.9MBPS	STARLAB (1.4) CRE (0.1)		STARLAB (1.4) IRI (1.5)

REQUIREMENTS SOURCES
28.5^0 INCLINATION FACILITIES

REQUIREMENT		PHASE/SOURCE 1990–1991	1995	2000
SS ATTACHED P/L POWER	9KW	SOT (6.8) LDSM (0.2)		
SS ATTACHED P/L PEAK DATA	60MBPS	SOT (50) STPE (10)		
SS ATTACHED P/L AVERAGE DATA	25MBPS	SOT (15) STPE (10)		
	31MBPS		ASO (21) STPE (10)	
SS MANNED LABORATORY VOL	36M^3	SM (4) MPL (4) ASB (4) IMLA (20) GSB (4)		
	56M^3		SM (4) MPL (4) ASB (4) IMLA (20) GSB (4) IMLB (20)	
SS MANNED LABORATORY POWER	8KW	SM (0.4) MPL (0.8) ASB (0.4) IMLA (4) GSB (0.4)		

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REQUIREMENTS SOURCES
28.5^{0} INCLINATION FACILITIES

REQUIREMENT		PHASE/SOURCE		
		1990-1991	1995	2000
SS MANNED LABORATORY DATA	5MBPS	SM (5) ASB (5) GSB (5)		

REQUIREMENTS SOURCES
97^0 INCLINATION FACILITIES

TRW

REQUIREMENT		PHASE/SOURCE 1990-1991	1995	2000
SP OR SS ATTACHED P/L POWER,	12KW	ESRM (6.5) RSP (2.5) AMWM-A (3.0)		
	31KW		STO (9.2) WINDSAT (8) RSP (7.5) STPV-A (3.6) AMWM-A (3.0)	
SP OR SS ATTACHED P/L PEAK DATA,	300–600MBPS	ESRM (150) RSP (100) AMWM-A (300)		
	300–750MBPS		ESRM (150) RSP (300) AMWM-A (300)	
SP OR SS ATTACHED P/L AVERAGE DATA,	132MBPS	ESRM (45) RSP (15) AMWM-A (72)		
	162MBPS		ESRM (45) RSP (15) AMWM-A (72)	

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REQUIREMENTS SOURCES
97^{0} INCLINATION FACILITIES

REQUIREMENT		PHASE/SOURCE		
		1990-1991	1995	2000
SS MANNED LABORATORY VOL,	$8M^3$	STPV(8)		
	$12M^3$			STPV(12)
SS MANNED LABORATORY POWER,	2KW	STPV(2)		

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SPACE STATION ARCHITECTURE SCENARIOS

Six different candidate scenarios were examined. All had free-flying spacecraft, small unmanned platforms, TMS and OTV's in common.

Scenario 0 is the baseline. This assumes neither SS or SP. It is what would/could be done without those elements. Scenario 1 adds Space Platforms. Scenario 2 has Space Stations, but no Space Platforms. Scenario 3 has an SS at LEO and one or more SP's at PEO.

Scenario 4 has SS's at LEO and PEO and an SP at LEO. Scenario 5 is like Scenario 4, except that an extended-stay Orbiter is used as part of the initial SS.

Space Station Architecture Scenarios

SCENARIO	SPACE PLATFORM		SPACE STATION	
	LEO*	PEO	LEO	PEO
0				
1	X	X		
2			X	X
3		X	X	
4	X		X	X
5**	X		X	X

*LEO – LOW INCLINATION (28.5°) LOW EARTH ORBIT
PEO – POLAR (97°) LOW EARTH ORBIT

**USES STS AS PART OF INITIAL SS

ALL SCENARIOS INCLUDE FREE FLIERS, SMALL UNMANNED PLATFORMS, TMS, OTV'S

MISSION ACCOMMODATIONS BY SS SCENARIOS

The phased mission requirements are developed with as little consideration of Space Station scenarios as possible. Each of the scenarios is then applied to the requirements and the appropriate number of facilities and Shuttle flights are employed to best meet the phased requirements. The effectiveness of the scenarios is then essentially measured in terms of relative costs. This chart identifies how the different mission categories: free-flying vehicles, space platform payloads, space station payloads, and manned laboratory are accommodated by the available facilities of each scenario. (The SUP, small unmanned platform, is used to accommodate payloads in scenarios where either the space station or the space platform are not available at the needed time or place.) As indicated, the principal difference between the scenario accommodations and the mission requirements is in the case of the manned laboratory. Without a space station, Scenarios 0 and 1 "best" accommodate the lab requirements by providing two Spacelab flights each year that allow up to four-weeks of lab operation per year. This is in contrast to the 52 weeks of operation afforded by Scenarios 2 through 5 that feature space stations and permanent manned laboratories.

MISSION ACCOMMODATIONS BY SS SCENARIOS

SCENARIO	REQUIREMENTS/ACCOMMODATIONS APPROACH			
	SERVICE FREE-FLYERS	ACCOMMODATE SPACE PLATFORM PAYLOADS	ACCOMMODATE SPACE STATION PAYLOADS	ACCOMMODATE MANNED LABORATORIES
0	STS	SUP	SUP	STS/SPACELAB (4 WEEKS/YEAR)
1	STS	SP	SP	STS/SPACELAB (4 WEEKS/YEAR)
2	SS	SUP	SS	SS
3	SS	SP	SS	SS
4	SS	SP	SS	SS
5	SS	SP	SS	SS

- ONLY MAJOR CAPABILITY IMPACT IS MANNED LAB ACCOMMODATIONS BY SCENARIOS 1 AND 2
- OTHER SCENARIO DIFFERENCES PRIMARILY ECONOMIC

SS — SPACE STATION
SP — SPACE PLATFORM
SUP — SMALL UNMANNED PLATFORM

Mission Benefits

MISSION BENEFITS

One portion of the mission analysis task within the space station study was the definition of benefits for the individual missions. These results were then incorporated into the overall study cost-benefits analysis.

The chart summarizes the ground rules and approach used in the analysis and identifies key benefit areas to be addressed in the following.

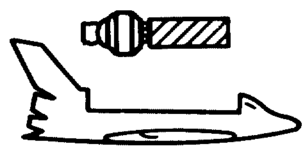
MISSION BENEFITS

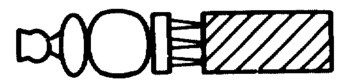
- EVALUATE TANGIBLE BENEFITS, BASICALLY COST SAVINGS FOR SPACE TRANSPORTATION
- CALCULATE BENEFITS ASSUMING "FREE" SS
- COMPARE BENEFITS VS SS IMPLEMENTATION, OPERATING COSTS
- FOLLOWING MOTIVATES CERTAIN KEY BENEFITS
  - ROTV TRANSPORTATION TO GEO
  - SERVICING GEO SATELLITES
  - MANNED LAB COST SAVINGS
  - SPACE ASSEMBLED VEHICLES, INSTRUMENTS
- FOR MORE COMPLETE ANALYSIS, SEE COSTING WORKING GROUP DISCUSSION

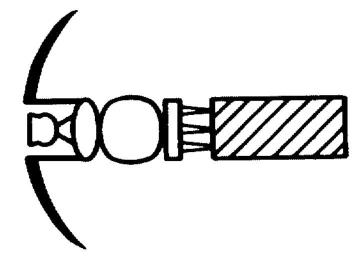
OPTIONS FOR TRANSPORT TO GEO

In the SS benefits studies, three options for transportation to geosynchronous orbit are considered: 1) an STS-carried upper stage using cryogenic propellants, 2) a space station-based returnable OTV (ROTV) that returns using all-propulsive maneuvers, and 3) an ROTV that returns from geosynchronous orbit using a perigee aerobrake maneuver to provide a portion of the mission velocity requirement (referred to as an AROTV). The representative characteristics and performances used in the study for each of these vehicles are shown in the facing chart. Each vehicle is assumed to have a payload capability of 12,000 lbs. This value is an estimated limit for the STS deployed geo-payloads. As indicated, the limit is due to STS cargo bay volume rather than lift capability. The ROTV's are sized to have this same payload capability to ease comparison. Note that the AROTV is heavier unloaded than the ROTV because of the aerobrake. The all-propulsive ROTV requires more propellant than the AROTV, however. Although it is conceivable that ROTV's could be deployed from the Shuttle or possibly left on orbit between Shuttle flights, it is judged in this study that the practical use of returnable OTV's require the availability of a permanent manned servicing facility in low earth orbit.

OPTIONS FOR TRANSPORT TO GEO







OPTION	STS-CARRIED CRYO STAGE	ALL-PROP ROTV	AERO-BRAKED ROTV
PAYLOAD, LBS	12,000	12,000	12,000
ISP, SEC	460	480	480
PROPELLANT, LBS	28,600	35,800	31,200
EMPTY VEHICLE, LBS	6,000	3,600	5,000
CARGO BAY LENGTH, FT	23	NA	NA
PERFORMANCE LIMIT	CARGO BAY VOL.	ROTV SIZING	ROTV SIZING

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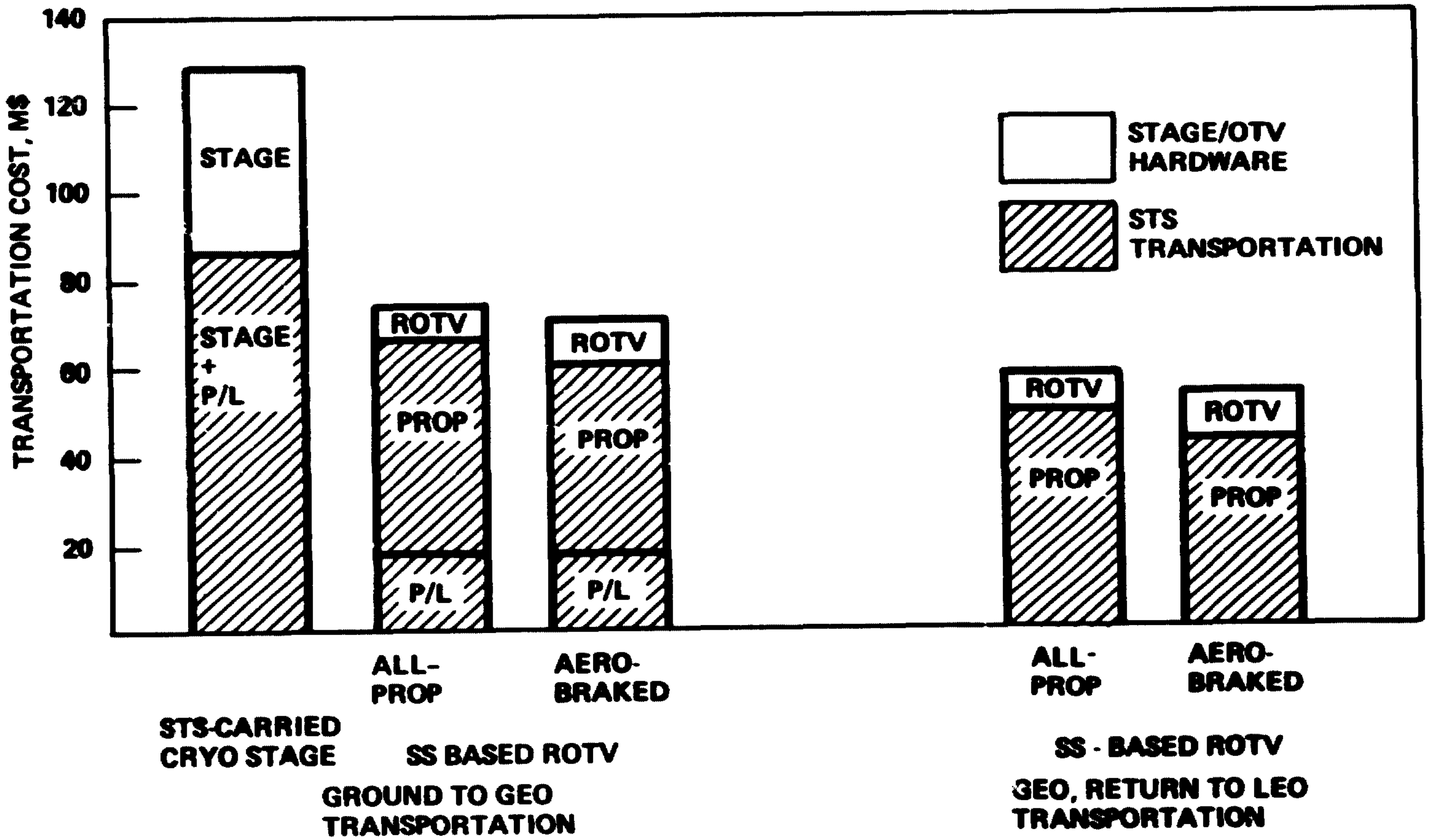
- 12,000 LBS PAYLOAD, PRACTICAL LIMIT FOR STS CARRIED CRYO STAGE
- ROTV'S SCALED TO 12,000 LB PAYLOAD FOR EASY COMPARISON

COST OF TRANSPORTATION TO AND FROM GEO ORBITS

Costs in 1984 $ are estimated for all of the transportation modes and options under consideration. The costs consist of, as indicated, OTV or stage hardware costs and STS transportation costs. In the case of the upper stage, the hardware cost is for purchasing a new, expendable vehicle ($42M). Hardware costs for the ROTV and AROTV ($10M and $7M, respectively) include amortized RDT&E plus new ROTV production and per-flight hardware costs (e.g., replacement of the aerobrake, if needed). No SS servicing costs are assessed in keeping with the "free space station" benefits evaluation approach. STS transportation cost is based on an $86M price per launch, 75 Klb. lift capability, and for the ROTV's, an overall 92% load factor. 15% FSE* is accounted for plus, in the case of the ROTV's, 10% propellant tankage weight. The two ROTV costs are very comparable and are both a significant improvement vs. the STS carried cryo-stage. The value of the AROTV over the ROTV enters in when evaluating the transportation rates of cost per pound of payload as shown in the next chart.

*FSE: Flight Support Equipment

COST OF TRANSPORTATION TO AND FROM GEO ORBITS



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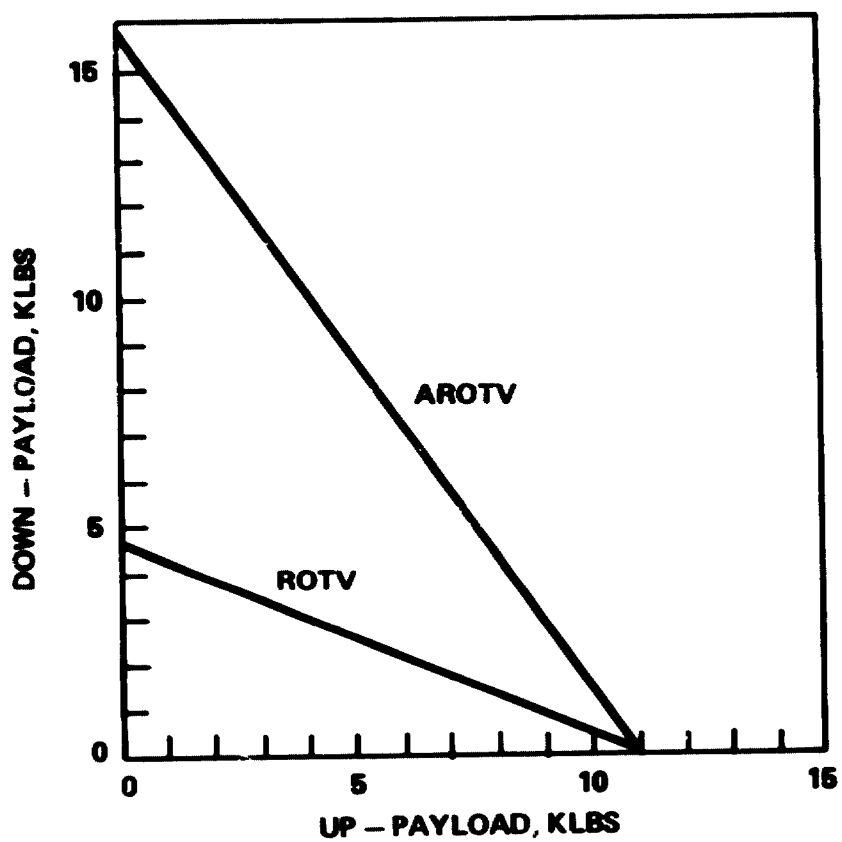
ROTV's REDUCE COST BY:
- REUSING HARDWARE
- AVOIDING STS VOLUME CONSTRAINT

RIDE SHARING TO/FROM GEO

A returnable OTV can carry payloads to and from geosynchronous orbit. The total payload capability is limited by the ROTV performance and can be apportioned between "up-payload" and "down-payload" as indicated in the accompanying chart. The two ROTV up-payload capabilities are, as intended, equal. The down-payload of the AROTV is much greater than the corresponding ROTV capability because of the efficiency of the aerobrake maneuver; in fact, the AROTV can return more payload (~15,000 lbs.) than it can lift to geo-orbit. As indicated on the graph, the payloads can be apportioned, and likewise the costs of the flight can be apportioned, according to the fraction of the vehicle capability that is being devoted to the particular payload.

RIDE SHARING TO/FROM GEO



AROTV: AERO BRAKED ROTV
ROTV. ALL-PROP ROTV

	ROTV	AROTV
DRY WT, LBS	3,000	5,000
ISP, SEC	480	480
UP - ΔV, fps	14,000	14,000
DOWN - ΔV, fps	14,000	6,000

- AROTV RETURNS 3 X PAYLOAD OF ROTV
- PAYLOADS TO/FROM GEO CAN SHARE RIDE
- COSTS CAN BE PRO-RATED VS ALLOCATED PROPELLANT

TRANSPORTATION RATES

The costs from the preceeding chart and the previously indicated payload capabilities are used to calculate transportation charging rates for each of the transporation modes of interest. A strong improvement of the ROTV's over the Shuttle upper stage and a greater than 3 to 1 improvement in return-from-GEO cost afforded by the AROTV over the ROTV are observed. Note that these rates are applicable to either fully loaded flights or they can be used as prorated costs in the case of shared loads, either to-, or from- geosynchronous orbit.

C-2

TRANSPORTATION RATES

CASE	PAYLOAD, LBS	COST, M$	RATE, K$/LB
TO GEO			
STS/CRYO STAGE	12,000	128	10.7
ALL-PROP ROTV	12,000	73	6.1
AROTV	12,000	70	5.8
FROM GEO			
ALL-PROP ROTV	4,500	56	12.4
AROTV	15,300	53	3.5

- ROTV'S REDUCE COST OF TRANSPORT TO GEO BY 40%
- AROTV INTRODUCES OPTIONS FOR REPAIRING/RETURNING GEO SATELLITES AT ACCEPTABLE COSTS

GEO-SATELLITE REPLACEMENT VS. SERVICING

The AROTV provides the potential for lower cost return-transportation from geo-orbits. This in turn introduces repairing and servicing of geo-satellites as a possible cost effective option. Two approaches can be considered: 1) returning a geo-satellite to low-earth orbit and servicing it at a space station, and 2) repairing the satellite or satellites at their geosync stations using an AROTV-transported automated repair vehicle. Both approaches have been evaluated; this chart details the costs of the repair-at-LEO option, a simpler, although not necessarily less costly approach than repairing at GEO. The cost is compared to today's satellite maintenance approach of replacing the satellite when it has failed or is nearing the end of its lifetime.

Both the replacement and service cases' costs are composed of transportation and satellite hardware and service costs. The transportation cost is based on the preceeding evaluations. The remaining costs are reasonable estimates used to assess the possible savings. SS servicing cost has been neglected in estimating the benefit. The estimated savings and hence the benefit of satellite servicing using the SS based AROTV is $56M.

GEO-SATELLITE REPLACEMENT VS SERVICING AT LEO (COSTS IN M$ FOR TYPICAL 5,000 LB VEHICLE)

	REPLACE SATELLITE		SERVICE SATELLITE
REPLACE H/W	85.0	ORU H/W	8.5
STS TRANSPORT TO LEO	7.2	GROUND SUPPORT	9.5
AROTV TRANSPORT LEO → GEO	21.8	STS ORU TRANSPORT	0.7
TOTAL	114.0	AROTV TRANSPORT GEO → LEO	17.5
		AROTV TRANSPORT LEO → GEO	21.8
		TOTAL	58.0

SAVINGS FOR SERVICING $56 M

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COMPARISON OF REPAIR AT LEO AND REPAIR AT GEO STRATEGIES

The cost savings of repairing geo-satellites is evaluated in terms of variations due to satellite weight and the choice of repair strategy; either using the space station at LEO or an automated repair vehicle at GEO. The variation with respect to weight accounts for cost variation by weight in the satellite hardware (assumed to be $17K/lb.) and in the transportation to and from GEO.

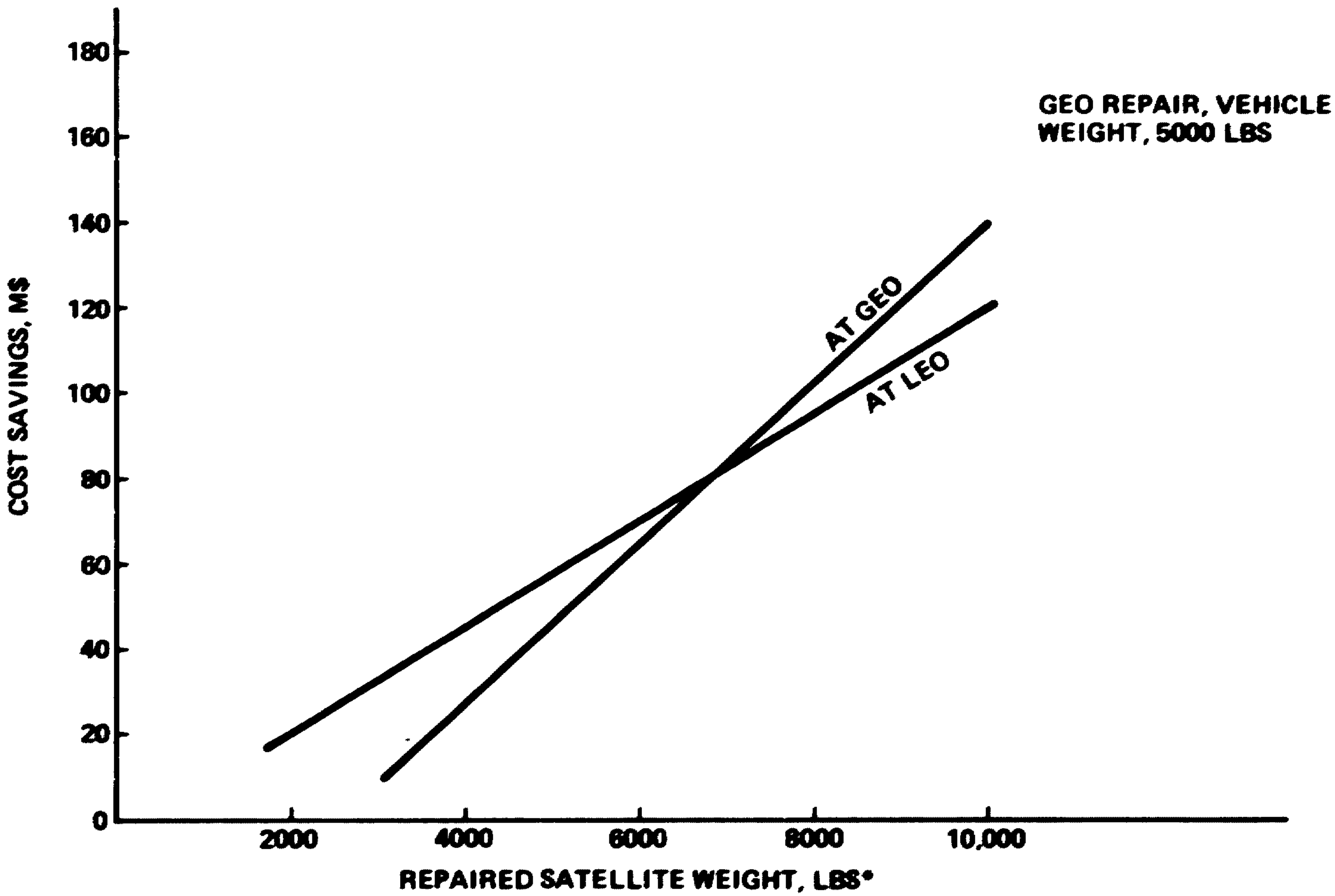
The chart indicates:

1. Repair of small, 1000-2000 lb. satellites is most likely marginal to not cost effective.

2. Returning satellites to LEO for repair is more cost effective than repairing at GEO, for satellites in the 2000 lb.-5000 lb. range; whereas, for satellites above 10,000 lb., the repair at GEO approach is favorable.

The second conclusion can be extended to multiple satellites where the "satellite weight" can serve as total weight for the multiple satellites. Thus, repair at GEO becomes favorable if a sufficient number of satellites of given size are repaired in a single repair mission. These results give rise to an evolutionary approach where satellite return to LEO and repair is employed first, giving way near the end of the decade to the repair of large and/or multiple satellites in geosynchronous orbit. This approach is based on the assumption that repair and servicing at GEO is a technologically more demanding task than retrieving satellites from GEO and repairing at LEO.

COMPARISON OF REPAIR AT LEO AND REPAIR AT GEO STRATEGIES



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*SINGLE SATELLITE OR TOTAL FOR MULTIPLE SATELLITE REPAIRS

SAVINGS FOR TYPICAL YEAR IN MISSION MODEL (1997)

The results of the preceeding analysis are applied to the space station mission model for a typical year, 1997. The effected missions are two large commercial communications satellite categories, the 2,000 lb- and 5,000 lb-class communications satellites, and the generic mission of DoD geosynchronous satellites with a representative weight of 6,000-7,000 lbs. The benefits of the SS-based ROTV and the servicing of geo-satellites at low-earth orbit are evaluated. The cost savings are calculated using the transportation rates given on page 120 and repair savings weight sensitivities given on page 124. The benefits are calculated so that they are additive, i.e., servicing vs. replacement assumes AROTV transportation rates.

Benefits due to these savings are $483M and $824M per year, respectively, for ROTV transportation and satellite servicing. The servicing savings are calculated using an assumed division between the number of replacement vs. new capability launches as shown in the chart. These benefits accrue in the cost benefits analysis starting in 1995 since it is assumed that the attendant AROTV and satellite servicing technologies will not be ready until then.

SAVINGS FOR TYPICAL YEAR IN MISSION MODEL (1997)

APPLICABLE MISSIONS	NO SERVICING	SERVICING	
	LAUNCHES	LAUNCHES	SERVICES
COMMUNICATIONS: 2000 LB CLASS	2	0	2
COMMUNICATIONS: 5000 LB CLASS	8	2	6
DoD: 6000 - 7000 LB CLASS	8	2	6
TOTAL LAUNCHES/SERVICES	18	4	14
TOTAL WEIGHT, LBS	98,600	23,200	73,600

SAVINGS:	1. AROTV VS STS/CRYO STAGE	$483M
	2. SERVICING VS REPLACEMENT	$824M

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COST OF SPACELAB FLIGHT

The benefit of the space station manned laboratory is measured by the cost savings from avoiding repeated Spacelab flights. The scenarios (0 and 1 on page 106) without a manned space station provide two, 14 day Spacelab flights to best accommodate the laboratory without a permanent facility. The cost of these flights are estimated in the chart.

COST OF SPACELAB FLIGHT (M$)

COSTS:

SHUTTLE LAUNCH	86.0
CRYO KIT	1.8
EXTRA DAYS (13)	16.2
INTEGRATION	12.0
TOTAL	116.0

- SS SAVINGS ASSUMING 2 SL FLIGHTS PER YEAR = $230M
- INTANGIBLE BENEFIT OF 52 VS 4 WEEKS DURATION NOT QUANTIFIED

SS LARGE INSTRUMENT ASSEMBLY COST SAVINGS

The chart evaluates the cost savings (vs STS-only) for an SS implementation of three large assembled instruments in the mission model, LDR, VLST, and IRI. The resulting savings are computed to be, in 1984$:

LDR: $243M
VLST: $273M
IRI: $153M

These cost savings are based on 1) a consideration of the operational requirements and 2) the hardware and design requirements that would be imposed on STS-only vs. SS implementations of the respective missions.

SS LARGE INSTRUMENT ASSEMBLY COST SAVINGS

MISSION	SS-IMPLEMENTATION ROM PROGRAM COST (M$)	STS FLIGHTS	DELTAS FOR STS-ONLY SCENARIO			
			CDT&E[1] (M$)	ASE[2] TRANSPORT (M$)	STS[3] DAY-CHARGE (M$)	TOTAL SAVINGS (M$)
LDR (20 M)	600	2	180	34	29	243
VLST	700	2	210	34	29	273
IRI	300	2	90	34	29	153

1. 30% OF ROM PROGRAM COST
2. 20% STS FLIGHT CHARGES AT $86 M/FLIGHT
3. $1.2 M/DAY, 12 DAYS PER FLIGHT

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MARS SURFACE SAMPLE RETURN (MSSR) COST SAVINGS

The MSSR savings are based on two implementation scenarios:

1) STS-only

- 1st STS flight deploys MSSR to LEO
- 2nd STS flight carries two, tanked Centaur-type upper stages and rendezvous with MSSR vehicle
- MSSR vehicle is assembled to upper stages
- Full assembly is deployed and launched to Mars

2) SS

- MSSR vehicle and dry Centaur-type stage launched on shared STS flight(s)
- MSSR plus upper stage are mated to AROTV and entire assembly is fueled at SS
- Full assembly is deployed by SS and launched to Mars
- AROTV provides partial velocity and returns to SS for reuse; upper stage provides remaining velocity for flight to Mars

The SS cost savings for the MSSR is $311 M.

MARS SURFACE SAMPLE RETURN (MSSR)

STS ONLY			
	1st STS FLIGHT (MSSR VEHICLE)	86	
	2nd STS FLIGHT (CENTAUR F+G)	86	
	STS FLIGHT DURATION CHARGES	7	
	2 CENTAUR STAGES	84	
	MSSR DDT&E DELTA COSTS	200	
	TOTAL		463
SS			
	STS COST (MSS + DRY CENTAUR, 31 KLB)	36	
	AROTV + CENTAUR FUEL (56 KLB)	64	
	AROTV HARDWARE CHARGE	10	
	CENTAUR HARDWARE CHARGE	42	
	TOTAL		152
		BENEFIT	311

TOTAL BENEFIT DISTRIBUTION

This chart is extracted from the spac station cost analysis working group briefing and summarizes total space station benefits distributed across the three user areas and the different benefit categories. The largest contributions to space station benefits are:

STS efficiency (load factor improvement)	$5.1B
Geosynchronous Satellite Servicing	$3.3B
Manned Lab Savings	$2.9B
AROTV Economies	$2.5B

TOTAL BENEFIT DISTRIBUTION
BILLIONS OF 1984 DOLLARS
SCENARIO 3

BENEFITS	SCIENCE AND APPLICATIONS	COMMERCIAL	DoD
AROTV	$0.0 B	$1.7 B	$0.8 B
GEO SAT SERV	0.0	1.5	1.8
MANNED LAB	1.0	1.9	0.0
STS LOAD FACTOR	1.9	2.3	0.9
LARGE INST ASSY	0.7	0.0	0.0
MSSR	0.3	0.0	0.0
LEO SAT SERV	0.5	0.0	0.0
MAT'L PROC	0.0	0.3	0.0
REMOTE SENSING	0.0	0.0	0.0
ON-ORBIT AI&T	0.2	0.3	0.2
COMSAT TRANSHIPMENT	0.0	0.8	0.0
UNMAN PLATF	0.7	0.6	0.0
	$5.3 B	$9.4 B	$3.7 B
	29%	51%	20%

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The overall conclusions of the TRW space station cost benefits analysis are briefly summarized. The economic benefits have been conservatively assessed and show a reasonable positive return into the 21st century. The true potential of the space station is measured in presently unquantifiable terms, not unlike the outcome of most national policy questions.

SS BENEFITS CONCLUSIONS

- SS IS SHOWN TO BREAK-EVEN IN 1997; POSITIVE RETURN OF $1.8 B/YEAR AFTERWARDS
- TRUE "PROFITS" FOR USA DERIVE FROM INTANGIBLES:
  - USA SPACE LEADERSHIP
  - ENHANCED US SECURITY
  - FOREIGN-US COOPERATION IN SPACE
  - LONG DURATION MANNED LAB POTENTIAL, E.G., MATERIALS, LIFE SCIENCE DISCOVERIES